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UNIVERSITY OF COLORADO

Semicentennial Publications

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Dedicated to
The Citizens of Colorado

ZOOLOGY OF COLORADO

BY

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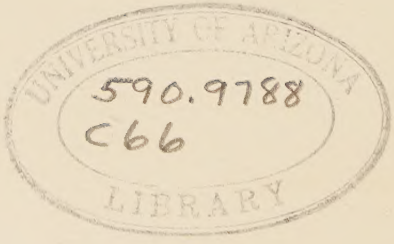

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Table of Contents

Chapter		Page
1.	The Past	1
2.	Mammals	15
3.	Birds	56
4.	Reptiles	104
5.	Amphibia	111
6.	Fossil Fishes	114
7.	Living Fishes	118
8.	Mollusca	127
9.	Insects	143
10.	Butterflies	209
11.	Moths	224
12.	Crustacea	233
13.	Worms	241
14.	Protozoa	247
	Alphabetical Index	255

Chapter 1

THE PAST

All the past these mountains saw
All the years of toil and strife
Lives unknown that went before
They gave us this: our present life.

Immediately west of Boulder the hills rise abruptly, exposing ancient sedimentary strata of various ages. Rocks which were originally almost or quite horizontal are now upturned, and in some cases quite on edge, at right angles to the original plane of deposition. No sudden catastrophe has brought this about, the slow movements of the earth's crust are usually not appreciable within our period of observation, but in the course of millions of years mountain ranges rise or are worn away, leaving in the rocks a record which can be interpreted by man. It is interesting to think that the drama of nature, during the long ages of the past, was incomprehensible to the beings peopling the earth; and yet as its result there has emerged a creature capable of looking back on the past with understanding mind, as the traveler on the mountain top surveys the road by which he came. It is as though the road led through dense jungles, in which it was possible to see a short distance in any direction, until the rising ground suddenly permitted a long range view to a distant horizon. Under such circumstances the traveler, though perhaps footsore and weary, would feel a thrill of exultation, and would eagerly note hills and valleys, rivers and lakes, and other features of the scenery. We are in precisely such a position, except that we now concern ourselves with time rather than space, and can thereby discern a history, in which events follow each other in orderly sequence, related as causes and effects. Our interest is further quickened when we realize that it is *our* history, without any metaphor; that we are what we are because of the things that were. The theory of the continuity of the germ plasm, now firmly established by innumerable observations, postulates the continuity of life itself from generation to generation throughout the ages. Offspring arise as particles of their parents, and although the vital forces appear to be at low ebb in the seed, spore or egg, they are never extinguished. In this sense it may be

truly said that we have witnessed the process of evolution from the beginning, dull though our perception of it may have been.

We who live in Colorado are exceptionally fortunate if we desire to understand the past. Several years ago an eminent geologist from Chicago was taken to the top of one of the University buildings. Looking about him, he remarked that it was possible to see more geology from this spot than in the whole state of Illinois. He referred to the variety of exposures, the diversity of the rocks, the contrasts in the topography, the number of different geological periods represented. When we travel over the State we find even greater diversities and contrasts; so that, for example, one familiar only with the front range seems to have reached a new and unfamiliar world when he examines the mesas and canons of the western part of the country. One who has collected fossils in the numerous strata about Boulder, has an entirely new set of plants and animals revealed to him if he digs at Florissant or searches the rocks of the oil shale country. Not only have wonderfully rich deposits of fossils been found, but as yet the work of exploration is exceedingly incomplete, so that the adventurous naturalist may still make discoveries of first class importance. Indeed, it is not necessary to be a trained naturalist in order to do this, though experience and judgment count for much.

The whole subject has taken on a new aspect in recent years, consequent upon the study of radioactive minerals. Fifty years ago there was an outstanding dispute between the biologists and the physicists, represented especially by Professor Huxley and Lord Kelvin, respectively. The biologists objected that the fifty million years or thereabouts allowed by the physicists since the earth became capable of supporting life was not sufficient for evolution. It was necessary not only to account for the known history of life, as revealed in the rocks, but perhaps for an equal or longer period before this, to explain the relatively advanced state of even the earliest well preserved organisms. For a long time there seemed to be no solution, but now the physicists themselves have discovered a whole new aspect of their science, and since the rate of change in certain minerals is known, it becomes possible, within rather wide limits, to estimate the actual age of sedimentary rocks. The results are astonishing; the estimates of geological

times may probably be increased tenfold at least, and the biologist, who formerly complained of lack of time, now has more than he can account for, and has to marvel at the permanence of living types from epoch to epoch, often with very little change. It is also certain that the geological column, as at present known, lacks many horizons, and these, with fossils new to science, may at any time reward the explorer. Standing near the rest house on Flagstaff Hill, at Boulder, and looking northward, we see two parallel ridges, running north and south. The higher and more western, known as Red Rocks, was laid down in Paleozoic times. The vegetation in those days, though highly developed and diverse, was of a relatively primitive type. The dominant insects were cockroaches, many of them of large size. Fishes abounded in the waters, while tailed amphibians, walking over the wet mud or sand, sometimes left impressions of their feet, which may be seen to this day in the rock. An animal known only by such tracks, very like those of the modern *Ambystoma* or Tiger Salamander, has been named *Limnopus coloradensis* by Professor Henderson.* The specimen described was found at Lyons. The more eastern ridge, beginning just back of the sanitarium, belongs to the lower part of the Cretaceous period, and is many millions of years later than the Red Rocks. In the interval between the two, mammals, birds and the higher flowering plants have come into existence. The mammals were small, the birds were toothed, but the plants included trees of modern aspect, similar to or not distinguishable by their remains from poplars, oaks, figs, laurels, hollies, beeches, etc. Thus the life of the earth had undergone a radical transformation, one carrying the promise of the modern world. Today one can pass from one ridge to the other in a few moments, and it is hard to imagine the great lapse of time represented by the interval. Where are the rocks which should represent that time? In part perhaps never deposited in this vicinity, because deposition in one place means erosion in another, and it is only in certain places, usually along coasts, that materials are laid down to form new strata. In part also, we may feel sure, deposited but subsequently eroded away, the very thick cretaceous beds being formed out of the disintegrated materials. This erosion is going on today,

*Gilmore (1926) records footprints referred to the same species (which he calls *Laoporus coloradoensis*) from supposed Permian rocks in the Grand Canyon of the Colorado, Arizona.

and evidences of it may be seen everywhere. East of the front range, there are exposures of Cretaceous rocks, belonging to a period when the country was at sea-level, and the foothills of today were represented by a sea-coast. Subsequently the land was elevated, and during Tertiary times many strange animals roamed over the plains. Deposits were formed along the river valleys, containing their bones. Continued erosion has very largely washed these away, but in places, as at Pawnee Buttes, a large section has been left undisturbed, the streams passing on either side. In such localities the student searches with success for evidence of the life of the past; while he readily imagines, by mentally continuing the horizon represented by the tops of the buttes, the enormous amount of material washed away, with it of course innumerable fossil remains. It was in the vicinity of Pawnee Buttes, in Weld County, that a party from the Colorado Museum of Natural History obtained, not very long ago, a fine series of the bones of large extinct mammals, including a kind of rhinoceros. A ranchman had been digging post holes, and chanced to throw out a fragment of bone, which at once suggested further investigation. Yet this clue would have meant nothing, would have led to nothing, had not Mr. Figgins and his colleagues of the museum noted the find, and proceeded to take advantage of their opportunity. They were fortunate in that the deposit was easy of access. Near Troublesome, in the mountains of Colorado, a well preserved fragment of the jaw of a fossil horse (*Parahippus*) was found in boring for a well. It is almost certain that other remains, certainly the rest of the broken jaw, are still buried in that locality. It may be that thirty feet underground there is a series of bones comparable to that obtained in Weld County. We do not know; but no one has the time or means to investigate.

The bones referred to are of course large and conspicuous, once uncovered. Other fossils, no less interesting, require keen eyes for their detection. One day Mr. J. T. Duce was walking in Lesser's brickyard, at Boulder. The rock there is Pierre Cretaceous, deposited in the sea, not far from the shore. He picked up a small piece of rock, containing a fragment of a marine shell, and saw in it what looked like the tip of an insect wing. The exposed piece was so small that few would have noticed anything at all; but when the fossil was carefully chipped out it proved to be the wing

of an entirely new genus and species of insect, which was called *Petropteron mirandum*,—the admirable wing in the rock. The insect of course belonging to the land, had by some misfortune got drowned in the sea, and buried in what was then soft mud. Probably a lifetime of searching in the brickyard would not produce another like it. Such are the chances of paleontology. In England the remains of a remarkable dragon-fly were found inside an ammonite, which is a marine shell long ago extinct. The ammonite itself had been washed out of the original rock, and redeposited in the boulder clay, which belongs to very recent geologic times. Thus we know that the ammonite first died, and then the dragon-fly, falling into the sea, was by some accident washed in to the dead shell, with enough mud to fill it up. The whole became fossilized, and the fossil, many millions of years later, was washed out of the deposit, and into a new one. Here it was eventually found by man, who by employing the brain which had in the meanwhile evolved, could tell the story as it must have occurred.

In the Loup Fork (Tertiary) beds of Kansas, bones of large vertebrates are found, but the conditions were not favorable for the preservation of plant remains. But inside a skull some hard seeds happened to lodge, and thus were preserved. They proved to be very similar to those of our modern "Snow-on-the-Mountain", and were named *Tithymalus willistoni*, after the eminent naturalist who first called attention to them.*

THE FOSSILS OF THE OIL SHALES

Leaving the train at De Beque, in Mesa County, and following Roan Creek toward its source, we pass up deep valleys, between high mesas which rise some two thousand feet on either side. On the top is a growth of sage brush, with occasional stands of Douglas spruce, while the depressions and draws, supporting more luxuriant vegetation, are the home of the glorious white columbine, a variety of the state flower of Colorado. So distinctive is this flower, appearing like stars against the green of the shrubbery, that it

*Samuel Wendell Williston, whose father had never learned to read or write, found his opportunity in the Kansas Agricultural College, under the stimulation of a teacher of science, Professor Mudge. Under Mudge he became a collector of fossils, at first for sport. In the course of a long and active life, he became one of the greatest living authorities on fossil vertebrates, and also the leading student of American flies (Diptera). He served as professor first in Kansas, later in the University of Chicago, communicating his enthusiasm to many disciples, who are still at work.

might pass for a different species, but for the occasional presence of a blue-flowered plant. Steep trails lead up the mountain side, or one may climb arduously up the shifting rock-slopes, to arrive at the top very short of breath. The tops of these mesas afford a splendid view of the surrounding country, but at certain seasons of the year the traveler is unmercifully persecuted by biting flies (*Symphoromyia*), blood sucking members of a group (Rhagionidae) which is otherwise quite inoffensive.

Some distance below the highest levels, or on the summits of the partly eroded spurs, we find a rather thick layer of dense gray rock, which will burst into flame on being placed in the fire. This is the famous oil shale, which will, in case of need, supply almost unlimited quantities of petroleum. In many places assessment holes have been blasted and dug, as though gigantic gophers had been burrowing in the mountain side. These excavations, costing large sums of money, furnish the paleontologist's opportunity. Here he finds great piles of the shale, which he has only to turn over or split in order to discover remains of plants and insects, sometimes beautifully preserved. The age is Eocene, in the earlier part of the Tertiary, and the particular division of the Eocene represented is known as the Green River. This last name is derived from the locality Green River, Wyoming, where beds of this period were first carefully studied. In Wyoming, at certain places, there is an amazing variety of beautifully preserved fish skeletons, which are often prepared as neatly trimmed slabs, and sold to visitors. In the Roan Mountains such fishes have not been observed, though polished ganoid scales of a kind of garpike (*Lepidosteus*) occasionally occur. This is a freshwater animal, and indicates freshwater conditions, though it is by no means certain that there were not saline lakes, into which freshwater organisms, or portions of them, were carried from rivers. We have not found any mammal bones in the oil shales, but it is a very extraordinary circumstance that maggots of a kind of bot-fly (*Lithohypoderma ascarides*) are exceedingly abundant over a very wide area, at a certain level. We can only suppose that these were parasitic on some mammal of the period, but at present the matter cannot be further explained. There is no doubt as to the nature of the maggots. Occasional feathers in the shale testify to the presence of birds. Sometimes these are ordinary small

contour feathers, which cannot be assigned to any particular sort of bird. On one occasion, long thread-like strands were found, closely resembling the plumage of the cassowary. It was inferred that these might belong to a species of *Diatryma*, a gigantic flightless bird of the Rocky Mountain Eocene, now well known from a skeleton found in Wyoming. Some of the paleontologists at the British Museum believe that the remains are really vegetable fibers, and not plumage at all, but it seems to me that they are mistaken. It is indeed possible to make mistakes in dealing with such fossils, and no less an authority than Lesquereux, who was an expert student of mosses as well as fossil plants, described a feather in the Florissant shales as a kind of moss, calling it *Fontinalis pristina.*

Of all the fossils in the oil shales the insects are the most interesting. In the first place, we have from the Green River formation about 300 different species, whereas for the Eocene deposits of all the rest of the world we know only about seventy. Then it must be noted that the Cretaceous or Upper Mesozoic has so far furnished only the most scanty and most imperfect remains of insects, and back of that the insect fauna is of a relatively archaic type. Thus the Green River shales furnish us with the first (earliest) modernized series of insects, and in spite of the fact that these rocks are many millions of years old, the aspect of some of the species is in no way more archaic than that of those we catch in Colorado today. The most striking illustration of this is found in a wasp (*Hoplisus archoryctes*) discovered in the rock at the head of Bear Gulch. It is as old as any wasp known, but its beautiful preservation with wings outspread, shows that it is as like the living forms of the genus as they are to one another. Even the clouding on the wings is the same. Since that wasp lived, the Himalayas and Swiss Alps have been raised to their present imposing dimensions, but the wasp-protoplasm has gone on faithfully reproducing itself with only minor or specific changes. It must not be inferred, however, that all the insects are of modern or ordinary types. The earliest known ants occur in these deposits, and one of them, (*Archimyrmex rostratus*), is a very singular creature belonging to the family Poneridae. The bull-dog ants of Australia, considered to be the most generalized of all living ants, had only one known fossil relative, which was discovered in Baltic

amber. Then we obtained *Archimyrmex* from the Colorado shales, still more ancient, but clearly of the same alliance. Thus it seems that there existed a race of ants widely spread over the world, which eventually failed except in Australia, where it still prospers. The case may be compared with that of the marsupial mammals, which were formerly world-wide, and now abound in Australia. There are however living marsupials in America, and it may be that some one will discover in the Andes or elsewhere a living member of the bull-dog ant group. Had we been living at the time represented by the shales, we should have noticed especially some very prettily marked and varied insects with broad wings, which might be taken for moths. As a matter of fact they are Fulgoroids, members of the Homoptera, more nearly related to the cicada. Such insects are common in the tropics today, particularly in India, but they have disappeared from Colorado, leaving only some dull and insignificant looking relatives. The preservation of the Fulgoroids is so good, that the patterns of the wings are as distinct as in life, though the bright colors are gone. It is curious that so far we have found no butterflies or moths in these deposits. What at first seemed to be a small moth was seen on closer inspection to be a caddis-fly. The old motto, *Natura maxime miranda est in minimis*, is exemplified by a minute fossil fly of the Roan Mountains, only 3.2 millimeters (about an eighth of an inch) long. It is so well preserved that many small details can be seen, indicating that it may well be an ancestor of the modern Agromyzidae. It has been called *Eomyza holoptera*, and while it is unlike any living fly, its characters are similar to those existing in various related species. Its scientific interest is mainly due to the following facts. Professor T. H. Morgan and his associates in Columbia University have for many years made an intensive study of the genetics of the fruit-fly, *Drosophila*. They have found very many mutations, and have been able to throw more light on the process of heredity than any previous workers. These classical researches have suggested that new species may arise rather rapidly through mutation, and in general that their evolution may proceed at a rate comparable to that of the mammals. Now the discovery of Eocene Acalyptrate Muscoids brings out the fact that, after all, the essential characters of these flies are extremely ancient, and have not been progressively changing throughout

Tertiary time. It appears rather that there has been a sort of kaleidoscopic shuffle producing indeed a host of different species, but little steady or progressive advance in type.

The accompanying fossil plants are of diverse types, but the flora differs from that of Florissant in including palms. The climate indicated is warm temperate, by no means distinctly tropical.

THE MIOCENE SHALES OF FLORISSANT

In the early seventies of the last century, a party of the United States Geological Survey was camped in an upland valley directly west of the base of Pike's Peak. The surrounding hills were known to be granite, and it was supposed that sedimentary rocks were lacking. Dr. A. C. Peale, while supper was being prepared, strolled about in the vicinity of the camp, and was surprised to pick up a well preserved fossil leaf. This of course led to further investigations, and it was soon ascertained that the whole valley was filled with fossilferous shales, derived from deposits of volcanic ash in an ancient lake. It was even possible to find old volcanic vents, and to map the outlines of the former lake, which had been drained by the tilting of the land, leaving only a small stream flowing down the valley. This stream, though of no great size, except when swollen by cloud-bursts, had been cutting into the soft shales for some millions of years, removing a large part of the deposit, and destroying innumerable fossils. As a result there were numerous places where the shale was exposed, or only covered by a certain amount of gravel, making it relatively easy to dig it out and split it into thin slabs. On such slabs are found not only fossil leaves, but many beautifully preserved remains of insects, occasional fish, and at extremely rare intervals a bird, though feathers are not uncommon. In 1877 Dr. S. H. Scudder, who was then the leading authority on fossil insects, spent the summer in this locality, which is known as the Florissant Valley. The little town of Florissant possibly got its name from that of a place in the vicinity of Geneva, and as it has to be referred to very frequently in scientific literature, we are thankful to the Swiss who may have remembered his ancestral home, and glad that no unromantic American thought to call the place Tin Cup, Hell Gate or

Bagdad. The collections obtained by Scudder were very extensive, and were eventually described and figured in large works published by the United States Geological Survey. The plants were similarly treated by Lesquereux, and the fishes by Cope. Thus this rather out of the way spot, known to comparatively few people in Colorado, became famous in the literature of paleontology, and is referred to in nearly all the text-books of geology. The age of the deposits was long a matter of dispute, and was difficult to settle for two reasons. In the first place the shale rests on a base of metamorphosed rocks, and is nowhere in contact with any of the fossil ferous strata. It is therefore impossible to secure direct proof that it is earlier or later than any previously known beds. In the second place we still lack remains of mammals, which of all fossils are the most satisfactory for marking time, owing to their comparatively rapid evolution. In spite of these difficulties, it is now generally agreed that the shales belong to the Miocene division of Tertiary time, and are therefore very much later than the oil shales of the Roan Mountains. This opinion has been reached through comparison with deposits of known relative age, and is fortified by other considerations. Thus it is known that during Miocene time there was continuous land from Asia to what is now Alaska, and the climate was much warmer than at present.

There was an extensive migration of the old world types into America. It is also known that at a later epoch North and South America, which had been separated, were united by land, and southern animals entered the northern continent. Now the Florissant fossils do indicate the presence of old world elements, which so far as we know did not exist in America earlier than the Miocene. But there is no clear indication of South American forms, and it appears probable that in the days of Lake Florissant the Isthmus of Panama was still under water. Reasoning of this kind depends upon the gradual accumulation of data, and what at first is suspected, later becomes probable, and eventually may be so well supported that a definite theory can be established. The Florissant problem is still subject to reconsideration from many angles, and every scrap of new information has its value as bearing upon the final solution.

Scudder's largest work was dated 1890, and his latest contribution to the knowledge of Florissant fossil insects appeared in

1900 (U. S. Geol. Survey, Monograph 40). The accumulated materials had not all been dealt with at that time, but failing health made it impossible to proceed, and for some years Florissant was neglected. It was currently supposed that the beds had been practically exhausted, and that little of importance remained to be done. In 1905 Professors Henderson and Ramaley, of the University of Colorado, visited Florissant, securing a small collection which included some hitherto unknown species. After this, there were expeditions in the field during several summers, the

Scorpion Fly (*Order Mecoptera*) Holcorpa maculosa, Scudder
Fossil at Florissant; collected at station 14 by Geo. N. Rohwer. Drawing by Ruth Isensee

work done through the cooperation of several individuals and institutions. The results exceeded expectations, and the beauty and interest of the specimens of plants and insects can hardly be exaggerated. The best exhibited series is in the Museum of the University of Colorado, but there are good collections in the British Museum and elsewhere. The publication of the scientific results has gone on at intervals, hampered by the cost of the necessary illustrations, and by the difficulty of getting the work done by some of the experts to whom portions have been entrusted. It is unfortunately true that some good fossils have been obtained by collectors who took no interest in the progress of science, and

have been set aside or even lost without falling into the hands of someone competent to describe them. It cannot be too strongly urged that materials of this kind are not to be regarded as mere private property, but should be placed where they will be studied, and saved for the use of posterity. In such localities as Florissant many of the specimens are unique, and will probably remain as the only evidence of the existence, ages ago, of the species they represent. The described species of insects from the Florissant shales number considerably over a thousand, while others have been collected and await description. Among the most interesting are four species of tsetse-flies (*Glossina*), which sucked the blood of Miocene mammals. In Africa, the nagana disease so fatal to cattle is due to a parasitic Protozoan (*Trypanosoma*) which is carried by a kind of tsetse-fly, *Glossina morsitans*. Sleeping sickness of man, which has wiped out whole communities in central Africa, is produced by another Protozoan, carried by *Glossina palpalis*. It is of course impossible to detect fossil Trypanosomes in the fossil tsetse-flies, but it may well be that they harbored them, and this may account for the mysterious extinction of some of the Tertiary mammals. The objection has been made, that in Africa the native mammals (antelopes, etc.) do not succumb to the nagana disease, but have actually acquired a tolerance of the Trypanosomes, so that they serve as reservoirs for the dangerous parasites, the flies carrying them from the wild animals to the domesticated stock. Therefore, it was argued, it ought to be expected that in Miocene times the tsetse-flies, even if carrying Trypanosomes, would not injuriously affect the wild animals. However, this does not take into account the Miocene migration, whereby the flies may have entered the country from Asia, and rapidly spread over it, causing disease in the native animals, which had never acquired immunity or tolerance. The living tsetse-flies are confined to Africa (with 17 species), except that one occurs in southern Arabia. Thus they were totally unexpected at Florissant, and when the first one, unfortunately headless, fell into the hands of Scudder, he described it as a member of the Œstridae, the family of bot-flies and warble-flies. In 1907 Mr. Geo. N. Rohwer found a good specimen, showing the proboscis, and there was little difficulty in determining its true nature. Such a surprising discovery was naturally met with

some incredulity, but every expert who has examined the specimens has been obliged to admit the correctness of the identification. In 1909 a second species was found, and in 1916 two more, so that we now have four species in all. Scudder's original species (*G. oligocena*) is the largest, with the wings about 16 mm. long. Next in size is *G. veterna*, while *G. osborni* and *G. armatipes* are smaller insects, with the wings less than eight mm. long.

On July 22, 1907, Mr. Sievert A. Rohwer was digging at Florissant, and discovered a very extraordinary fossil insect, beautifully preserved, with wings outspread. The broad rounded upper wings, which had an expanse of about 64 mm., resembled in a general way those of a dragon-fly. The hind wings, about 44 mm. long, were narrow and strap-shaped, except for a broad rather fiddle-shaped expansion at the end. Mr. Rohwer at once made a sketch, and sent it to me with a letter in which he said: "The above insect caused a great deal of excitement this afternoon just before a severe rain storm. In my limited experience I am at a loss to know what family it belongs to." It was perfectly clear that it represented a family unknown in North America, but did such insects exist elsewhere? On looking the matter up, there was no difficulty in referring the specimen to the Neuropterous family Nemopteridae, well represented in various parts of the old world. The larva, a very extraordinary animal with a long slender neck, has been found about the tombs and pyramids of Egypt. The family was totally unknown in the Western Hemisphere, except for a single species discovered in Chile. The known distribution of the family had been analagous in some respects to that of the camel group, represented in the Old World, and (by llamas) in the Andean region of South America. Such discontinuous distribution might appear contradictory to the theory of evolution, but for the fact that Camelidae are known to have abounded in North America, the fossil bones of many species having been discovered. Now the similar anomaly presented by the Nemopterids was made intelligible by the discovery of a fossil species in Colorado. This remarkable fossil was referred to an Old World genus, and named *Halter americana*. Some years later, Longinus Navas, a Spanish authority on Neuroptera, decided that it should be placed in a separate (extinct) genus,

which he thereupon named *Marquettia*, dedicating it to the famous Père Marquette.

The varying fortunes of fossil-hunting are well illustrated by Mrs. Cockerell's discovery of a fossil butterfly. The only known fossil butterflies of the Western Hemisphere are those from Florissant, Scudder having described a number of species. For a long time our luck in this direction failed, our most productive diggings produced no butterflies. One day the lunch was forgotten, and the party strolled toward the village, taking a somewhat unusual path. A little of the shale was seen sticking out on a hillside north of the sawmill, and Mrs. Cockerell sat down and turned over a piece. There was the long desired butterfly, a beautiful specimen showing the spots! It proved to be a new species, and was named *Chloripppe wilmattae*, after its discoverer. Many times we returned to that place, but without any success. The butterfly probably flew out into the middle of the lake, far from the shore line where most of the remains of dead insects and leaves accumulated. Altho the specimen is a very good one, the abdomen and hind wings are missing, perhaps eaten by a fish when the insect fell into the water.

Some idea of the richness of the Florissant beds may be gathered from the fact that in 1912 Professor H. F. Wickham of the University of Iowa dug a trench about 20 feet long and six feet deep. Out of it he got over 90 species of beetles, of which more than 40 were new to science. He also got undescribed insects of other orders.

The Florissant flora, preserved in the shales with the insects, includes species of redwood, fig, holly, magnolia, elm, beech, walnut, chestnut, maple, poplar, pine, oak etc., indicating a warm temperate climate. There are well preserved flowers and fruits, and a great silicified redwood stump. A rosebud was found, and leaves of several species of roses.

Chapter 2

MAMMALS*

The origin of the Mammalia, or hairy warm-blooded animals was many millions of years ago, in the earlier part of the Mesozoic age. The fossil cynodont (dog-toothed) reptiles of South Africa seem to point the way to mammalian evolution. They had, at all events, two occipital condyles (articulating with the first vertebra), and their teeth were distinctly differentiated into incisors, canines, premolars and molars. The duck-bill of Australia is a mammal which retains the reptilian feature of laying eggs. Where the first mammal actually developed, we do not know, and probably never will know, but some very ancient and primitive forms have been found in Rocky Mountain strata. These animals were small and insignificant, while the reptiles, represented by gigantic dinosaurs, appeared to be lords of the earth. In a Drama of Evolution we have imagined a conversation between the dinosaur *Brontosaurus* and a primitive mammal;

Brontosaurus.

But look you, little beast, your blood is warm,
Your skin is hairy, and though small you swarm
Through glade and forest.
In all past since Cambrian dawn,
Through all the changeful weary days,
Enduring night for hopeful morn,
Was never such a craze. You do upset
The whole great scheme of progress, and forget
The lessons of the elder days.

Primitive Mammal.

Great sir, we see in you and yours
Creation's finished work. 'Tis not for us
To emulate your greatness. Yet we would try
A line of progress all our own, and by and by
In ages yet to come evolve a man,
A being who with winged thought may span
The starry skies, and as in time he dies
Soar thither as a soul!

*See especially E. R. Warren, The Mammals of Colorado (1910).

At the end of the Mesozoic the dinosaurs disappeared, and the true Age of Mammals began. But we do not find in the western rocks a record of continuous progress and development. Instead, we have evidence of successive waves of invasion, new types which had evolved elsewhere coming in to supplant the old, much as the white man has supplanted native tribes in various regions, or as modern man (Homo sapiens) supplanted the Neanderthal man ages ago in Europe. Owing to these invasions, and the comparatively rapid evolution of the mammalia, the bones of these animals afford us more accurate means of discriminating between successive strata than any other fossils. It is thus of great interest to collect all the materials available, both to demonstrate evolution and reach a better understanding of geology. The mounted specimens in the Colorado Museum in City Park, Denver, give us a lively realization of the former mammalian life of Colorado, and appeal to the imagination of all intelligent persons. Looking at them, we readily understand that in addition to the invasions and evolution already mentioned, there is another matter to consider, namely extinction. Genera and families, even orders, have gone out as well as come in. Thus we have additional date lines for the identification of strata. This coming in and going out may have often taken quite short periods, as we know to have been the case within historic times. Thompson Seton has given us a vivid account of the destruction by disease of the rabbits in the Mackenzie region of British America. Where millions existed recently, he could not find a single individual. Consequently the Canada lynxes, which had multiplied on a rabbit diet, were actually reduced to starvation. In such cases it is generally found that a few animals survive, and eventually the species which reached so low an ebb is restored to at least temporary prosperity. But as we know well from the records of the past, this does not always happen, and many an interesting animal has disappeared, never to return. Can we be absolutely sure that man himself will not suffer such a fate? The world-wide influenza epidemic, which killed more than the great war, may be taken as a warning. Among the mammals of which we have a fairly complete evolutionary history, the horse group stands pre-eminent. This is particularly satisfactory because the horse is really a very peculiar animal, the origin of which, in the absence of direct information, would

be hard to imagine. Several years ago Mr. G. T. Bruce found in Cuchara sandstone of the Huerfano four well preserved teeth, which we found to belong to *Eohippus*,—the name means horse of the dawn. Later, Miss Louise Lacy found *Eohippus* teeth on a small hill five miles from Rifle. These remains pertain to an animal barely a foot high at the shoulder, looking something like a small dog. It had four toes on the front feet and three on the hind, a reduction from the primitive number of five toes on each foot. The artist C. R. Knight, trying to picture it as in life, represents it as spotted, but this is of course conjectural. It was at all events a forest-living animal, with feet adapted to soft ground. Why should this be called the horse of the dawn? It was no more a horse than a monkey is a man; it does not even belong to the same subfamily (Equinae) as the modern horse. Yet between this creature and the true horse we have a series, so nearly bridging the great gap that naturalists see in the *Eohippus*, if not an actual ancestor of the horse, at any rate the representative of a group from which the latter must have come. A much later and more advanced type, the *Parahippus*, was found fossil at Troublesome and on Pawnee Creek. In all, about seventeen species of fossil Equidae, members of the horse family, have been discovered in Colorado, but before the time of Columbus this race of animals was apparently quite extinct in America. The wild horses mentioned in American history were the progeny of the domesticated animals run wild.*

The Elephantidae or elephants, coming from the Old World by way of what is now Bering Strait, reached Colorado during the Miocene. In 1923 Osborn described a species (*Rhynchotherium rectidens*) from the Middle Miocene near Pawnee Buttes. It was based on the upper tusks. The year before, Harold Cook described two species of the Mastodon group, *Trilophodon hicksi* and *T. paladentatus*, from a despoit near Wray, Yuma County. The specimens, consisting of lower jaws, are in the Colorado Museum at Denver. *Rhynchotherium* is peculiar for the fact that the end of the lower jaw is directed downward, perhaps to enable the animal more readily to uproot trees with its lower tusks. In *Trilophodon* this is much less conspicuous, though there is a

*Species of true *Equus* (*E. complicatus* and *E. laurentius*) did however exist in Colorado in Pleistocene times (Hay, 1924).

moderate tendency of the same sort. The long parallel lower tusks make one think of a plow. All these animals, owing to the structure of their teeth, readily fall in the Mastodon series, which is very distinct from the typical elephants, so that Osborn places them in a different family, and even establishes a superfamily (Mastodontoidea) for them.

The true elephants, including the mammoths, are not derived from these American mastodons, but evidently came to this country from Asia at a later date. The large hairy elephant known as the mammoth was contemporaneous with man in Europe, and its remains, with the hair and flesh still preserved, have been found in the ice of Northern Siberia. Paleolithic man engraved and painted the mammoth with skill, showing its characteristic outlines and long hair. A very remarkable engraving, on a piece of tusk, shows an enraged mammoth charging, its tail elevated in the air. There is a complication of outlines which have been taken to indicate, in more or less shadowy form, three mammoths instead of one. It seems very likely, however, that the artist wished only to show rapid motion, and had in fact the germ of the idea of the moving picture. More than one species of mammoth existed in the United States during Pleistocene times, indeed about five kinds have been more or less clearly diagnosed. It appears that at least two of these existed in Colorado. In the Museum of the University of Colorado we have a good specimen of *Elephas imperator* of Leidy, the imperial mammoth, from about four and one-half miles northeast of La Veta. It was obtained by Professor R. D. George and Mr. E. A. Strange on the T. J. Arrington Ranch. A specimen which seems to belong to *Elephas jeffersoni* of Osborn (*E. boreus* of Hay) was presented to the University Museum by Mr. George Helmer, and came from west of Littleton. Many of the mammoth remains, variously fragmentary, have been found in different parts of the State, indicating the former abundance of the great animals. The best way to distinguish *E. imperator* from *E. jeffersoni* appears to be by the ridge-plates on the molar teeth. In *E. imperator* these plates are wider apart, about five being crossed by a line 100 millimeters long; whereas in *E. jeffersoni* such a line would cross seven or eight of the plates. The general effect of more crowded ridges is evident in the latter species. Osborn (1924) has recently

Skull of *Uintacolotherium blayneyi* Cook, (Order Amblypoda) Fossil in the Eocene Strata of Moffat County, Colorado, and now preserved in the Colorado Museum of Natural History. Actual length a little over three feet.

Colo. Mus. Photo

proposed to remove these animals from *Elephas*, placing *E. imperator* in *Archidiskodon* of Pohlig and *E. jeffersoni* in *Parelephas* of Osborn.*

Long before the elephant group reached America, this land was occupied by other huge mammals, the Titanotheres. It was long supposed that this superfamily was confined to North America, but more recently remains apparently referable to it have been discovered in Europe. Numerous Titanotheres, described by Osborn, Cope, Leidy and Marsh have been found in the earlier Tertiary strata of Colorado. They appear to have died out near the middle of Oligocene time; for what reason, we do not know. In appearance, the Titanotheres were more like rhinoceroses than any other animal known to us. The rhinoceroses have of course survived in Asia and Africa, but they formerly abounded in America, several species existing in Colorado. In the Colorado Museum of Natural History, two skeletons have been cleverly mounted, with a restoration on one side, looking like a modern stuffed specimen, and the bones exposed on the other side. One of these, from Weld County, is called *Trigonias osborni;* the other, from Yuma County, is *Teleoceras fossiger*. Additional details, with figures, are given in the Scientific Monthly for September 1923.

In any review of the extinct animals of Colorado, we should not omit the Camelidae, the family of camels and llamas. It was long ago recognized that the South American llama and vicuna were allied to the Old World camel and dromedary, a very surprising fact in view of their wide separation. The key to the mystery was supplied when it was discovered that members of this group formerly spread all over North America, which was in fact the place of origin of the whole series. Extending their range across Asia, the camels finally reached North Africa, while the llamas, going southward, found a home in the Andes. It is as if mankind and his civilization perished in Europe, to survive in America and New Zealand. It has not rarely happened that a once dominant and wide-spread race has been reduced to a few forms occupying regions remote from the original home of the

*Hay (1924) enumerates several Colorado records of the *Elephas columbi* of Falconer, but Osborn shows that this species has been confused with others. In true *E. columbi*, according to Osborn, the ridge-plates of the teeth do not exceed six in 100 mm.

group. The tracing of these migrations, extinctions and survivals is a fascinating pursuit for those who have the necessary imagination and philosophic insight.

One genus of extinct camel, the *Alticamelus* or "high-camel," was a most extraordinary creature. It had a long neck almost like that of a giraffe, and must have been able to browse off comparatively tall trees with ease. Members of this genus existed in the region east of the Rocky Mountains during Miocene and Pliocene time; remains of two species have been found on Pawnee Creek. There were true camels in North America as late as the Pleistocene. We are, geologically speaking, only a little too late to see camels and mammoths on our plains or in our mountain parks. By a similarly narrow margin we have missed the great ground-sloth, *Mylodon*. This belongs to the order Edentata, a South American group which invaded North America in Tertiary times. The name, implying the absence of teeth, is quite inappropriate for the ground-sloth, which has large teeth. The armadillo, still living in Texas, belongs to the Edentata. A kind of ground-sloth seems to have been contemporaneous with man in South America, and pieces of its hairy skin, found in a cave, may be seen in the British Museum. About a mile south of Walsenburg, Mr. E. A. Lidle found a large skull which belonged to some unknown animal. After his death, Mrs. Lidle kindly presented it to the University of Colorado, and we were much interested to see the first actual proof that ground-sloths lived in Colorado. The specimen is remarkable for its great size, the length being somewhat greater than that of any of the many examples obtained from the asphalt beds of the Rancho la Brea near Los Angeles, California. The Walsenburg skull was described and fully illustrated in the University of Colorado Studies, June 1909.

It can hardly be doubted that man reached America from the Old World. In this matter tradition and zoological evidence appear to agree. Until very recently, it was supposed that the Anthropoid Primates, the group of the gorilla, chimpanzee and orang, never existed on this side of the world. Consequently there was some stir in scientific circles when in 1922 Professor H. F. Osborn announced the discovery of an Anthropoid in the early Pliocene of Nebraska. The animal, called *Hesperopithecus*

haroldcooki, or Harold Cook's western monkey, is known only by a couple of molar teeth. To announce such a surprising discovery on such a small basis was of course to invite criticism, and this was not wanting. Nevertheless, subsequent and very minute studies seem only to confirm the original determination, which must apparently be regarded as valid. Gregory and Hellman (1923) go as far as to hint that *Hesperopithecus* may be actually ancestral to man, which if verified might tend to establish the genus *Homo* as of American origin. Even were this true,—and it seems extremely improbable—, it would still presumably be a fact that true or modern man, *Homo sapiens*, reached America from Asia. The original *Homo* must have been of a more primitive type, more resembling those species of Hominidae which have been found fossil in Europe and Asia, but never in America. Although the *Hesperopithecus* has as yet only been found in Nebraska, he or it must have roamed over Colorado, and we may be fortunate enough to find further remains in this State. The discovery of a skull of this creature would be an event of the highest importance, instantly claiming the attention of intelligent people the world over.

In a catalogue of the living mammals of Colorado, it is quite proper to include man. Linnaeus, a century before Darwin's Origin of Species, did not hesitate to include man in the animal kingdom, in the same order (Primates) as the monkeys. We were given the scientific name *Homo sapiens*, the wise or knowing man, though it must be confessed that we have not always quite lived up to it. Linnaeus even had the conception of a human progenitor, which he called the wild man, and described as "tetrapus, mutus, hirsutus," four-footed, without speech, and hairy. Dr. D. S. Jordan, in his Manual of the Vertebrates, says that this is the "typical var. *sapiens*," which if accepted would prevent us from using the designation for modern mankind! For the wild man of Linnaeus, if not mythical, must have been founded on legends of the higher apes. We should then have to fall back of the next designation, and call the species *Homo americanus*.* Actually, *Homo sapiens americanus* of Linnaeus is the proper name for the aboriginal man of Colorado, the so-called Indian.

*We, the white men of European origin, would be *Homo americanus europeus* (Linnaeus). But G. S. Miller (1924) considers *europeus* to be typical *sapiens*, and therefore a superflous name.

He represents what in zoology we call a subspecies; a group of individuals with evident distinguishing characters, but intergrading with the other groups of the species. This "intergradation" is not due to the existence of a series of tribes perfectly connecting the great divisions of mankind, but to the fact that interracial marriages are fertile and produce fertile offspring. There is, as we put it, no physiological barrier between the subspecies. It is thus out of the question, as much on biological as on sentimental or religious grounds, to recognize more than one species of existing man. As to social and psychological differences, they are still subject to dispute. Descriptive sociology and psychology may reveal numerous marked racial characteristics, but events have shown that these may often be modified within a single generation. What are the biological, hereditary, irreducible differences, we do not clearly know. We can no longer assent to the naive and simple classification which describes Europeans as governed by law, Americans (Indians) as regulated by customs, Asiatics governed by opinion, and Africans by caprice!

The nearest relatives of man now living in Colorado are the bats (Order Chiroptera) and insectivores (Order Insectivora). The bats are quite numerous, about sixteen different forms having been reported. Since the publication of Warren's Mammals of Colorado (1910), Miller has defined a new form of the little brown bat, calling it *Myotis longicrus interior*. It has been obtained at Grand Junction and Coventry in our State, and is paler than the typical *M. longicrus*, being tawny-olive above, slightly paler below. The original and therefore typical *M. longicrus* was from Puget Sound, a region of heavy rainfall where animals and birds tend to be of dusky hue. The generally pallid character of bats in the arid region is indicated in the names of some of our Colorado species. Thus we have *Antrozous pallidus*, the pale bat, described from El Paso, Texas, but extending into southern Colorado. Then there is *Eptesicus pallidus*, better called *Eptesicus fuscus pallidus*, described by Young from a specimen collected at Boulder. It does not appear quite certain that this is more than a peculiar individual, but it is in line with the general tendency mentioned. *Corynorhinus macrotis pallescens*, the pale big-eared bat, was first found in Arizona, but it

is not uncommon in Colorado. It is known by its very large ears, much longer than the head, and joined across the forehead. Those who obtain specimens of this bat should search them for the singular parasitic fly, *Trichobius corynorhini*, which appears to occur only on this species. The first specimens of the fly were obtained from a bat collected in the Great Sphinx Mine, Boulder County, by J. J. Blanchard.

The Colorado Insectivora are few, and not very well known. The Colorado mole, found in the northeastern part of the State, as at Wray, is called *Scalopus aquaticus caryi* of Jackson. It was distinguished as a subspecies as recently as 1914, and is named after Merritt Cary, who has done much work on Colorado mammals. The water shrew, *Neosorex navigator* of Baird, is found in our mountains, and swims with ease, as its name would suggest. I have seen it not far from Long's Peak Inn, moving rapidly beneath the surface of the water. Ordinarily shrews, the genus *Sorex*, are found in northern regions all round the world. They sometimes get into houses, and seem to be fond of milk, in which they are occasionally found drowned. People confuse them with mice, but the pointed nose and sharp teeth are very distinctive. Our species need further study, and specimens should be collected whenever the opportunity offers. Estes Park is the type or original locality* for *Sorex tenellus nanus* of Merriam, a small creature with a total length of a little over four inches. Warren records that the masked shrew, *Sorex personatus*, was taken on Pike's Peak at an elevation of 14,147 feet. This must be a very "conservative" animal, in the sense of not changing under diverse conditions, for it was originally described from the Eastern United States. It really seems astonishing that a shrew found in New England should be identical with one from the mountains of North Carolina on the one hand, and Pike's Peak on the other. Yet authors have described some subspecies; one from North Dakota, one from Labrador, and two from Alaska.

CARNIVORA

The carnivorous animals constitute an important element in our fauna, on account of their variety, size, and many interest-

*The type locality is the place from which the original material from which the species was described came. If the materials come from more than one place, a particular specimen should be designated as the type proper, or holotype, and its locality is the type locality. Specimens of the same species from the type locality are called topotypes.

ing characteristics. We have in Colorado the families Felidae (cats), Canidae (wolves and coyotes), and Mustelidae (skunks, badgers, wolverenes, martens, minks, weasels and others). The cougars or mountain lions were formerly considered to belong to a single species, but this is now divided, although the characters used are not very striking. Our Colorado animal is called *Felis oregonensis hippolestes* of Merriam; "hippolestes" means a robber of horses. The English naturalist Pocock in 1917 proposed a new classification of the cats, recognizing a number of genera. Dr. J. A. Allen, in an important paper published in 1919, followed this system, with certain amendments. On the new basis, the mountain lion belongs to the genus *Puma* of Jardine, and is *Puma oregonensis hippolestes*. Our other Felidae are the bobcats, the genus *Lynx*. Three species occur within our limits; the Canada lynx, with very large feet, and the tip of the tail black all round; Bailey's bobcat, with smaller feet, and the black mark at the end of the tail only a crescent; and the mountain bobcat, differing from the last in having two or three blackish bands on the upper side of the tail before the tip. Bailey's bobcat (*Lynx baileyi*) was originally described from Arizona, but has been found in Baca and Las Animas Counties, Colorado. Warren describes the tail as having one blackish and one fulvous band before the black tip. The mountain bobcat (*Lynx uinta*), was described in 1902 from Wyoming, but it seems to extend all over the mountainous region of Colorado, as far as Custer, Delta, Montrose, Grand and Routt Counties. The Canada lynx, *Lynx canadensis*, occupies the Hudsonian Zone, in the dense timber, and ranges from Colorado northward. Its large feet enable it to travel rapidly over soft snow, in spite of its weight. But the snowshoe rabbit is similarly provided, and so has a reasonable chance for its life. In past ages, larger cats inhabited Colorado, preying upon the large animals then living. Mr. Harold Cook (1922) has described from the Pliocene of Yuma County an animal with the skull 310 mm. (over a foot) long. It is related to the sabre-toothed tigers, and perhaps preyed upon the ground-sloths, becoming extinct when they perished, though at present we do not know of its survival into the Pleistocene. Its name is *Machaerodus* or *Heterofelis coloradensis*. The subgeneric name (*Heterofelis*) proposed by Mr. Cook will probably be accepted in

a generic sense, true *Machaerodus* belonging to the Old World. The specimens may be seen in the Colorado Museum at Denver.

Another very interesting extinct carnivore is *Ursavus pawniensis*, discovered by Childs Frick in the mid-Miocene beds near Pawnee Buttes. The generic name *Ursavus* implies an ancestral bear, but as Frick has recently (1926) shown in admirable detail, the animal belongs to an extinct group (Hemicyoninae) and is not a bear.

The dog family (Canidae) is represented in Colorado by three genera, *Urocyon* (the word literally meaning tailed dog), *Vulpes* and *Canis*. The gray fox is *Urocyon cinereoargenteus scotti* of Mearns, a cumbersome name indicating that our animal belongs to the subspecies described from Arizona, and not to the eastern representative of the genus. The gray foxes, with their large bushy tails, are beautiful animals, and run into a number of distinct species or races. There are no less than four forms peculiar to as many islands off the coast of California. The true foxes, *Vulpes*, include with us the western red fox *Vulpes macrourus* of Baird, and the swift fox, *Vulpes velox* of Say. The former, much the larger of the two, is found high in the mountains; the latter occurs on the plains. The swift fox was one of the many discoveries of Long's expedition, and another was the gray wolf, *Canis nubilus* of Say. The type locality of the latter is in Nebraska, but Warren states that wolves appear to be found all over Colorado, though they seem to be more abundant in Wyoming.

The coyotes also belong to *Canis*, but are placed with the jackals in a subgenus *Thos*. Warren cites five kinds of coyotes as reported from Colorado, but their separation is made with difficulty. Formerly these animals were referred to a single species, *Canis latrans* of Say, first found in Nebraska during Long's expedition. In 1897 Dr. C. H. Merriam wrote a paper in which he named supposedly new coyotes from Nebraska, Nevada, Utah, Arizona, Lower California and Mexico. This led to much controversy, and a debate was arranged in Washington between Merriam and Theodore Roosevelt, the latter maintaining in a friendly spirit that the subdivision was needless. One who was present stated that the feeling of the meeting seemed to be with Roosevelt, yet there is no doubt that the critical studies of Merriman have been of great value.

Although the coyote is a common animal, it has been difficult to secure and perhaps still more to take care of sufficient specimens, representing various localities and the pelage of different seasons. Dr. D. G. Elliot said in 1901, "it is difficult to distinguish these varieties of the coyote by any description, and still more so by skins and skulls." Mr. Warren writes that he fully agrees with Elliot.

Many fossil Canidae have been found in Colorado, belonging to several genera. Several are discussed by Thorpe in American Journal of Science, 1922, pp. 426-430. In the same year Harold Cook described a new form (*Porthocyon pugnator*) from the Pliocene of Yuma County. This was a dog-like animal, with a relatively high forehead and short muzzle, suggestive of the profile of some of the domesticated dogs.

The bears (Ursidae) have given rise to even more difference of opinion than the coyotes. The common bear of Colorado is *Euarctos americanus* of Pallas, generally known as the black bear, though it may be either black or brown. This is a smaller and much less formidable animal than the grizzly. The latter was called *Ursus horribilis* in 1815, the name based on the description by Lewis and Clark, of the bears they observed in Montana in 1805. Dr. C. H. Merriam, making a careful study of the skulls of bears, came to the astonishing conclusion that there are, or were very recently, over eighty kinds of grizzly and big brown bears in North America. The question then arose, what was true *Ursus horribilis*, the original grizzly bear? The animal had apparently been exterminated, but by great good fortune, Mr. E. S. Cameron of Marsh, Montana, had preserved a skull, practically from the original locality. From this Dr. Merriam was able to definitely identify *Ursus horribilis*, which was an animal of the plains of eastern Montana and the Dakotas, probably not entering Colorado. This species is however represented in the mountainous districts of Colorado by a subspecies which Merriam has called *Ursus horribilis bairdi*, dedicating it to the memory of S. F. Baird, who was one of the pioneers in the study of American mammals. The type locality is Blue River in Summit County, and the type skull is the one figured in Warren's "Mammals of Colorado." Still other Colorado bears have been named by Dr. Merriam *Ursus planiceps* (exact locality uncertain), *U.*

Grizzly Bears; the large one at right center from the Shoshone River country west of Cody, Wyoming; the others from Navajo River, Archuleta County, Colorado. Specimens in Colorado Museum of Natural History — Colo. Mus. Photo

macrodon (Twin Lakes) and *U. shoshone* (Estes Park). Of these four large bears, *bairdi* is considerably the largest, the basal length of the skull in old males being 348 mm., whereas in the others it is 320 or less. *U. macrodon*, a species of the higher mountains, is described by Merriam as "peculiar for a grizzly, resembling some of the Alaska brown bears; general body color rich brown, almost reddish brown, darker on hump and lightly washed with pale tipped hairs on upper part of back, head rather uniform brown." The basal length of an old male skull was 312 mm., thus a little smaller than *planiceps* or *shoshone*. *U. planiceps* and *U. shoshone* are known from skulls alone. The former was based on a skull collected by Dr. F. V. Hayden, perhaps in the foothills or along the western edge of the plains. Compared with *U. macrodon*, the zygomata of *planiceps* are very much more broadly outstanding and outbowed, and the molar teeth are decidedly smaller. *U. shoshone* is placed in a different group, with the skull rather high instead of flattened; it extends north into Wyoming. The interorbital breadth of these various bears (old males) is 72 mm. in *macrodon*, 75 in *planiceps*, 78 in *shoshone* and 81 in *bairdi*.

It would appear from the above that Colorado is (or was) plentifully supplied with bears, but it is not impossible that others will be detected. There are five kinds known from Wyoming, two from New Mexico, two from Arizona, and one each from Utah and Texas, not yet reported from Colorado. The number of available skulls has not been great enough to settle all the problems presented by these bears, so every additional specimen will be of great value and interest. Unfortunately Dr. Merriam does not figure any of the four Colorado species in his revision.

The family Procyonidae is represented by the raccoon, *Procyon lotor* of Linnaeus. In Turton's edition of the Systema Naturae (1806) we are informed that it "inhabits northern parts of America, in hollow trees; eats eggs and shell fish; washes its food, and carries it to its mouth with the fore-paws; sense of smell and touch exquisite; memory tenacious; sleeps from 12 at night till 12 in the day; climbs easily; fearful of hog's bristles; brings 2-3 young." Warren notes that it is very fond of corn when it is in milk, and in California raccoons have been known

to raid melon patches. According to Warren the young number three to six. These animals are not often seen in Colorado, on account of their nocturnal habits, but are widely distributed. Mr. Warren informs me that they are rare south of the Arkansas-Platte divide.

The ring-tail, family Bassariscidae, is somewhat related to the raccoon, but is easily known by the more slender body, and the annulated tail as long as the body. It has been found in Mesa, Montrose and San Miguel Counties. Its scientific name is *Bassariscus astutus*. Originally the genus was named *Bassaris*, but as this name had earlier been given to an insect, Dr. Coues in 1887 altered it to *Bassariscus*.*

The large family Mustelidae is divided into a series of subfamilies; Mustelinae for the martens, weasels and minks; Guloninae for the wolverenes; Lutrinae for the otters; Mephitinae for the skunks; and Taxidiinae for the American badgers. The last two subfamilies are exclusively American, and the existing genera are known to be as old as the Pleistocene. The other three groups are represented by genera which occur on both sides of the world in northern regions, the weasels and otters also reaching South America. The otters are of course aquatic, feeding on fish; they are very rare in Colorado. *Lutra* is the genus to which the otter belongs, and consequently Wagner in 1841 gave the name *Lutreola*, little otter, to the semi-aquatic mink. It is however so far from being an otter that it belongs with the weasels, and in Miller's classification (1924) *Lutreola* is made a subgenus of *Mustela*. Its webbed toes and naked soles of the feet are adaptations to aquatic life; but the teeth agree with the weasels, and the skull is not broadened as in the otter. Warren says that the mink "is found all through Colorado wherever there is sufficient water, ranging up to between 9,000 and 10,000 feet at least. It is quite common in many places, being found along the plains streams as well as in the mountains."

The typical weasels, stoats and ferrets constitute the genus *Mustela* in the more restricted sense. There is unfortunately

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*When a generic name has been previously used in zoology, it is said to be a homonym, and a new name must be provided. It is not now customary to make any change if the name has only been used previously for a plant, though it may be inconvenient to use the same name for both. Thus a certain bee, called *Prosopis*, may visit the flowers of the mesquite, also called *Prosopis*.

some confusion in the application of this name, arising from the fact that Linnaeus included a variety of different animals under it. Warren uses *Mustela* for the martens, and *Putorius* for the weasels, but I follow Miller's more recent work and call these genera *Martes* and *Mustela* respectively. No less than four kinds of weasels occur in Colorado. The large black-footed ferret (*Putorius nigripes*), with the feet and band across the face black, stands apart from all the others as the only American representative of the subgenus *Putorius* in the strict sense. This is the group containing the European polecat, of which the English ferret, used for catching rabbits, is generally supposed to be a domesticated variety. The ferret is generally yellowish-white, whereas the polecat is a dark brown, with the under parts darker than the back. Linnaeus regarded the ferret as a distinct species, calling it *Mustela furo*, apparently from the "red, fiery eyes."* It was alleged to inhabit Africa, and to have been brought to Europe in a state of domestication. Miller, examining ferret skulls, found that they were not like those of the common polecat, but agreed with the Asiatic species, *Mustela eversmanni*. This seems to lead to a curious complication, whereby *M. furo*, being the earlier designation, becomes the nomenclatural type of the species, and the wild animal has to be called *M. furo eversmanni*. The American ferret or polecat, found in Colorado, is a much paler animal than the European, with the under parts somewhat lighter than the upper, as is usual among mammals. The differences so impressed Trouessart that he made it the type of a distinct subgenus, called *Cynomyonax*, meaning "king of the prairie dogs." His conception of regal functions was interesting, for it feeds on the prairie dogs, following them into their holes.

The other Colorado weasels are smaller, and turn white in the winter. The European stoat or ermine is a member of this group, ermine robes being made from the white skins and the black tipped tails. Our smallest species, *Mustela streatori leptus* of Merriam, first discovered at Silverton, is only nine and one-half inches long. It has also been taken in Larimer, Boulder, Gunnison and Montrose Counties. Mr. Warren writes that he has one from El Paso County. The remaining two are the long-

*It has also been suggested that the name came from the Latin fur, a thief: but furo furui, is the Latin verb to rage.

tailed weasel, *Mustela longicauda*, over 15 inches long, light brown above in the summer; and the mountain weasel, *Mustela arizonensis*, appreciably smaller and much darker. The former belongs to the plains, the latter to the mountains, though reaching the edge of the plains. Although Dr. Mearns named the mountain weasel *arizonensis*, because it was first found near Flagstaff, Arizona, it goes north as far as British Columbia.

The beautiful bridled weasel of New Mexico (*Mustela frenata neomexicana*) is believed to extend to southwestern Kansas, and may yet be detected in the southeastern corner of Colorado.

The Rocky Mountain marten, *Martes caurina origenes* of Rhoads, was first described from a specimen collected on Marvine Mountain, Garfield County. Its color is brown, with the throat and breast yellow or orange; the tail is long and bushy. The premolar teeth are four on each side, above and below, instead of three as the weasels. Martens are noted for living in trees, and preying on birds and squirrels. The wolverene, or glutton, *Gulo luscus* of Linnaeus, is a powerful animal of considerable size, the total length about 39 inches. Its appearance is suggestive of a small bear, except for the thick bushy tail; and it is singular that Doran, examining its ear-bones, found that the incus was very like that of a bear. Linnaeus said it was very fierce, seizing beavers by surprise. Miller (1912) remarked that although it was usually regarded as closely related to the Mustelinae, it might probably find its true relationship with the African ratel(*Mellivora*). Our Colorado wolverene has always been referred to *Gulo luscus* described from Hudson Bay, but the German zoologist Matschie described no less than four supposed new wolverenes from North America in 1918. One of these, called *G. bairdi*, came from North Dakota, and if really distinguishable may be the form we have here.

The American badger forms a genus (*Taxidea*) distinct from that of Europe. Warren says it is found over the whole of Colorado, up to the timber line, and refers all the specimens to the typical *Taxidea taxus*. More recently, (1918) Figgins has separated a new subspecies, *T. taxus phippsi*, the type locality being northeast of Chromo, Archuleta County. It may also be noted that the subspecies *berlandieri* of Allen (1895) came from the Llano Estacado of Texas, near the border of New Mexico. *T. t. phippsi* is darker and larger than *berlandieri*, with a broader skull.

Our skunks belong to three distinct genera, easily known by the color pattern. In the large or ordinary skunks (*Mephitis*) there are two white stripes on a black ground. In the White-Backed Skunk (*Conepatus*) the back is entirely white and the snout is elongate. In the spotted skunks (*Spilogale*) there are four stripes, which are interrupted so as to give a spotted effect. Of *Mephitis* we have two kinds, the northern plains skunk, *M. hudsonica* of Richardson, and the long-tailed Texas skunk, *M. mesomelas varians* of Gray. Mearns' White-Backed Skunk (*Conepatus mesoleucus mearnsi* of Merriam), although a large and very conspicuous animal, was only recently added to the Colorado list. In 1891, Warren recorded a specimen found on Little Fountain Creek, southwest of Colorado Springs. He tells me that Mr. F. W. Miller of the Colorado Museum of Natural History reports a specimen taken in Furnace Canyon, on a tributary of Carrizo Creek, Baca County. This latter, proving to have distinctive features in the more massive skull, has been separated as a subspecies *C. mesoleucus figginsi* of F. W. Miller (Journ. of Mammalology Feb. 1925.) Four species of spotted skunks are described by Warren. The prairie spotted skunk, *Spilogale interrupta* of Rafinesque, has been found only at Wray. It is known by the absence of a white tip to the tail, this being present in the other three. The Arizona spotted skunk, *Spilogale arizonae* of Mearns, has been found at Salida and Coventry; it is the smallest of our species. The Rocky Mountain spotted skunk, *Spilogale tenuis* of Howell, has been taken in Estes Park, at Arkins and Boulder and, as I learn from Mr. Warren, near Colorado Springs. The Great Basin spotted skunk, *Spilogale gracilis saxatilis* of Merriam, was described from Utah, and occurs in western Colorado.

Skunks show a great deal of self-possession, as if aware of their disagreeable qualities. On one occasion, many years ago, I spent a night in a very small log cabin at the Micawber mine, in the Sangre de Cristo Mountains. The owner of the place, who was away, had asked me to try to shoot the mountain rats which infested it. I accordingly went to sleep with a loaded shot-gun by my side. Now there had formerly been a cat, for which a small square hole had been cut in the door. In the middle of the night I woke up, conscious that something was moving in the cabin. Sitting up I saw a fine skunk (*Mephitis*), by the light of

the moon shining through the window. The animal examined the premises with the utmost composure, as though fully aware that if I annoyed it I should have to spend the rest of the night outside. As soon as it disappeared through the door, I jumped up and took a shot at it as it ran. But it seemed to realize that it was not so safe outside, and made all haste to a pile of rocks, among which it made its escape. The English naturalist A. R. Wallace, in his Darwinism, tells of meeting a skunk, which showed as little fear as some tame animal. He instanced this as an illustration of warning coloration, the skunk's black and white advertising it and its qualities to all passers-by.

UNGULATA

The ungulates or hoofed mammals are represented by three families and four genera in Colorado at the present time; or five genera if we include the bison, abundant within the recollection of men still living. The families are Bovidae (sheep and oxen), Antilocapridae (pronghorns or American antelopes) and Cervidae (deer). The bison or so-called buffalo was named *Bos bison* by Linnaeus, the name being based on the form in northern Mexico. In 1827 Hamilton Smith proposed a genus *Bison* for this animal, which accordingly becomes *Bison bison**. In the Mackenzie Region of British America the bison are larger and darker, and have been separated as a subspecies *athabascae*. It is also said that the extinct animal of the Eastern States was appreciably different, and it has been proposed to call it *pennsylvanicus*. The European bison or wisent (*Bison bonasus*) is very similar in appearance, as may be noted at the New York Zoological Garden, where both species are exhibited. The oxen (including the bison) belong to an Old World group, which appears to have reached America in quite recent geological times. Fossil bison of the Pleistocene period have been found in numerous localities in the United States, and these belong to several species. Thus, according to Williston (1897) there were during this epoch no less than three kinds of bison in Kansas. Hay (1923) concludes that the extinct *Bison occidentalis* of Lucas lived in Minnesota at least until the middle

*There is however some confusion in the names employed. The *Bos bison* of Ray was the European bison, and the name Bison originally belonged to the wisent. Accordingly Gmelin (1788) called our bison *Bos americanus*, and this name has been widely accepted. Sherborn (Index Animalium) cites *Bison* G. Edwards in Catesby, 1771, as the earliest valid use of this generic name.

of the last glacial stage. The history of the bison, then, is apparently as follows. Some time during the late Tertiary the genus *Bison* evolved from the true oxen (*Bos*) in the northern part of the Old World. Reaching America, the bison had time to split up into several species, which roamed over what is now the United States. During the glacial period, or soon after, all these became extinct except the one kind now living. This, owing to the depredations of the European species of *Homo*, which had invaded the country, was nearly exterminated. But some members of that pernicious (from the bison's standpoint) race regretted what had been done, and took measures to keep the species alive, with very good success.

The sheep and goats are placed in a subfamily Caprinae, *Capra* being a goat. This, however, excludes the American Mountain Goat, which is not a true goat, but belongs to the genus *Oreamnos* in the subfamily Rupicaprinae, being allied to the European chamois. Another genus of this group is the Asiatic *Naemorhedus*, which includes the serow and goral. In 1899 Cragin reported that he had found traces of this genus in the Pleistocene of Colorado, and called the extinct species *N. palmeri*, after General Palmer of Glen Eyrie*. The Rocky Mountain sheep, *Ovis canadensis*, is placed in the same genus as the domesticated animal. It inhabits the higher mountains, coming down into the valleys during cold and snowy weather. This splendid animal is now protected, and in the spring it is often possible to approach near enough to flocks in the Estes Park region to take good photographs. As with the Bovinae, we have here another Old World group, which has invaded America very recently, geologically speaking. Probably because the sheep inhabit mountain ranges, and therefore tend to become isolated in colonies, they have split up into numerous variously diverse species and races. The last catalogue of North American mammals (1924) cites no less than eighteen kinds of mountain sheep, two of these inhabiting the States of Chihuahua and Sonora (Mexico) respectively, while another lives in Lower California.

The American antelope is called *Antilocapra americana*, the generic name meaning antelope-goat. It is in fact neither an

*Mr. Warren writes that these bones are now in the U. S. National Museum, and that Mr. Gidley states that they do not belong to *Naemorhedus*.

antelope nor a goat, but forms a distinct family, confined to North America, where it has existed since Pleistocene times. The horns are shed each year, but are formed on permanent horn-cores. Warren notes that the first European to see this animal was Coronado in 1535; but it was not until 1815 that it received a scientific name. It is of course a typical member of the plains fauna, and were it not for regulations made for its protection, it could not long survive in the presence of modern firearms. The white rump makes it very conspicuous to our eyes, and may serve a useful purpose in assisting the antelope to keep together at night. The suggestion has been made that from the position of a pursuing wolf or mountain lion, the white patch against the sky breaks the outline of the animal, and makes it hard to see clearly. The artist Thayer was the leading exponent of such views, and while he made important contributions to the theory of protective coloration in animals, it must be said that he carried his ideas to extremes*.

It now remains to consider our deer or Cervidae. The American elk or wapiti, *Cervus canadensis*, is closely related to the red deer of Europe, but the antlers are distinctly different. It is wrongly called the elk, this name belongs properly to the moose. Formerly it was abundant in the mountains of Colorado, but now it is greatly reduced in numbers. In the vicinity of Boulder it was exterminated, but has been established again from the herds kept under protection in Wyoming.

The American deer (*Odocoileus*) form a genus quite distinct from the Old World deer, and in fact more related to the reindeer and moose. The generic, specific and subspecific names used for the Colorado deer were all invented by the eccentric naturalist Rafinesque, who, about a hundred years ago, had a passion for naming plants and animals. So eager was he for novelties, that certain of his associates played practical jokes on him, describing imaginary creatures for which he published names. His personal peculiarities, and often reckless scientific work, caused him to be regarded with very little favor, so that his life appeared to be a

*"Thayer's Principle", which certainly is valid, explains why most mammals, birds and fishes are darker above than below, or at any rate shows that they gain by this coloration. Every fisherman knows, for example, that a live trout in the stream is more or less inconspicuous, appearing gray all over; but a dead fish, floating belly up, appears brilliantly white. Thayer enunciated the principle that the light color below compensates for the lessened illumination, the shaded parts appearing about as dark as the well lighted back. The result is to make the animal inconspicuous.

failure. We now know that with all his absurdities he had some sound ideas, in advance of his time. Posterity, neglecting the rubbish, preserves whatever is of worth, and thus Rafinesque comes to his own.

It was by a sort of accident that Rafinesque became the author of the generic name *Odocoileus*, now so important in American zoology. He based it on an upper premolar tooth of a deer, found in a cave at Carlisle, Pennsylvania. The name meant hollowed tooth, and it was supposed that the animal was extinct. Actually, it was the tooth of an ordinary Virginia deer; and as no generic name had then been provided for the American deer, this was available. The western whitetailed deer is *Odocoileus virginianus macrourus* of Rafinesque, while the black-tailed or mule deer is *O. hemionus* of the same author; both names published in 1817. Warren gives the following characters for their separation: *O. v. macrourus;* ears moderate, about half length of head; tail brown above, white below; antlers with a large subbasal snag; beam forwardly directed, the anterior branch the largest and longest; glands on the metatarsus short, about an inch long. *O. hemionus;* ears large, two-thirds to three-quarters length of head; tail white with a black tip; antlers with short subbasal snag; beam upwardly and outwardly directed forking dichotomously, with branches approximately equal; glands on the metatarsus about five inches long. The black-tailed deer is the common Colorado species, found almost everywhere in the mountains. The white-tailed deer, once locally common, is now extremely rare. Although we are unfortunately not able to include the moose among the animals of Colorado, it does exist in Wyoming. A new subspecies (*Alces americana shirasi*) was described by E. W. Nelson in 1914, from about four miles south of Yellowstone Park. It is a much paler colored animal than the typical northern moose.* Mr. Warren writes that he has investigated all alleged records of moose in Colorado, without being able to verify any of them.

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*Nelson says: "In consideration of his remarkable work in originating modern methods of flash-light photography of birds and mammals and the interest he has awakened, through this and his writings, in animal life and its preservation, I take pleasure in offering a well-deserved tribute by naming this fine game animal in honor of George Shiras, 3d." Mr. Shiras published an account of this moose, with illustrations, in National Geographic Magazine, July 1913.

RODENTIA

The rodents are the most successful mammals, if success is measured by the number of genera, species and individuals. Colorado is the home of a great variety of these animals, always easily distinguished from other orders by the teeth. The total absence of canine teeth shows them to be an end group, not leading to any other. Twenty-eight species and subspecies of rodents have been described as new from Colorado specimens. Of these, three were published in 1823, one in 1852, three in 1855, and one in 1857. These dates belong to the periods of Say and Baird. Next follows an interval of over 30 years, when no additions were made. When the writer came to Colorado in 1887, it was supposed that the rodents were well known, and I had no idea of the long series of discoveries which the future would reveal. But a new Colorado form was described in 1890, one in 1891, three each in 1893 and 1894, one in 1897, one in 1899, one in 1905, one in 1907, three in 1908, one in 1909, and one each in 1912, 1914, 1915 and 1918. It must be explained that the large number of additions is due to the refinements of modern mammalogy. Not only have good series of specimens been collected, but the analysis of these materials has been much more thorough. The modern period may be called the Merriamian, for it was Dr. H. C. Merriam who was mainly responsible for initiating the new methods. Europeans were at first scornful, but at length came to appreciate what was being done. Consequently, arrangements were made for G. S. Miller of the U. S. National Museum to go to England, and prepare for the British Museum a work of over a thousand pages describing the mammals of Western Europe. This work, certainly one of the classics of zoology, employs the same methods of minute analysis which had become customary in America.

The characters employed in all this work have been the external features of form and color, and the skulls and teeth. There is very much more to be done, on the various skeletal features, the auditory ossicles, and the numerous characters of the soft anatomy. In 1913 a study of the intestines of Colorado rodents was published.* It was recorded that the absolute and

*Cockerell, Miller and Printz, The Relative Lengths of the Large and Small Intestines in Rodents; Proc. Biol. Society of Washington, Dec. 20, 1913.

relative lengths of the large and small intestine were characteristic of genera and species, and yet showed extraordinary variation. Inasmuch as the intestines are constantly in use, one might suppose that natural selection would have kept those of each species near to an optimum length, whatever that might be. Instead of that, there is probably no part of the body, unless it may be the liver, which shows so much variation. It appears that some portions of the soft anatomy are not as essential as might be imagined, and that there may be superfluous lengths of intestine, serving no important purpose. My former teacher, Sir John Bland-Sutton, has just published a paper in which he shows that the human gall-bladder, if diseased, may be safely removed.*

In the gopher *Cratogeomys castanops* we were surprised to find that the large intestine is longer than the small; the large varying from 48.3 to 61 cm. the small 34.3 to 47 cm. Subsequent studies by Miller and Printz, not published, showed that the same thing is true of the vole *Microtus mordax* from Eldora. The large intestine in this animal varied from 51.5 to 58 cm., the small from 41.8 to 46 cm. The ratio of five specimens, taking the small intestine as 100, was 122:100, 123:100, 123:100, 123:100, 130:100. We were curious to know whether this condition obtained in other species of *Microtus*, and Mr. H. E. Anthony was so kind as to measure some specimens (in alcohol) of *M. pennsylvanicus*, with the following result: large intestine 29.5 to 37 cm. small 27 to 37.5 cm. Of the three specimens examined, two had the large intestine longest; but the third, an adult female, had the large 37 cm., and the small a trifle longer, 37.5 cm. It will be seen that in spite of the great variation, these figures are in complete contrast with those obtained from many other rodents, such for instance as the house mouse and the Norway rat. In the house mouse the usual measurements are about 9 cm. for the large intestine and 40 for the small. In the Norway rat the large intestine is from 10 to 18% of the small. Intermediate ratios are found in the white-footed mice; thus *Peromyscus maniculatus rufinus* had the large intestine 37 to 57% of the small. A white-

*British Medical Journal, Nov. 1, 1924. "The mere loss of the gall-bladder is unattended with sinister consequences. Many mammals and birds lack a gall-bladder. Some parrots have a gall-bladder and some not. Absence of the gall-bladder neither causes inconvenience nor shortens life."

footed mouse of a different genus (*Apodemus*), which I obtained on the Kudia River in Siberia, showed a similar ratio; large intestine 14.5 cm., small 35 cm.

Other interesting features are found in the caecum or blind sac at the junction of the large and small intestines. It is the reduced portion of this which is known in man as the vermiform appendix, and is the seat of appendicitis. In the house mouse, musk-rat and mountain rat the enlarged sac extends beyond the point where the small intestine enters it, and invades the beginning of the large intestine. In the house mouse the transition to ordinary large intestine is gradual, but in the other two it is abrupt. In the musk-rat and mountain rat the caecum is very long; in the rock squirrel and Colorado chipmunk (*Eutamias quadrivittatus*) it is much shorter and broader. In the white-footed mice the caecum is larger than in the house mouse (*Mus*), but does not invade the large intestine, Striking differences were found between the species of white-footed mice, but we do not know whether they would be constant in larger series. Thus *Peromyscus rowleyi* showed a caecum about 34 mm. long and comparatively narrow; in *P. rufinus* it was much shorter and very broad; in *P. nasutus* it was extremely short and broad, with a large rounded extension beyond the beginning of the large intestine, but not invading it. A similar gibbous basal extension, not so large, was found in the kangaroo rat, *Perodipus montanus*. The stomach in the three species of white-footed mice just mentioned showed a constriction separating the pyloric end from the remaining portion. In our only specimen of the grasshopper mouse, *Onychomys pallescens*, there was a double constriction, producing a tri-partite stomach. But in the house mouse, Norway rat, kangaroo rat, chipmunk (*Eutamias operarius*), guinea-pig, musk-rat and rock squirrel there is no constriction at all. The porcupine (*Erethizon*) was examined by Printz, and he found a sac with a basal constriction at the pyloric end, but not leading to the duodenum, being in fact a sort of pyloric caecum. The heart, lungs, and liver are no less interesting. Thus in *Onychomys pallescens* the right inferior lobe of the lungs has a small pointed lobule (*lobulus azygos*) beneath. The same is true of *Peromyscus rowleyi* and *Eutamias quadrivittatus*, but the lobule is absent in *Perodipus montanus*.

It will be obvious from the above that the anatomy of our rodents affords a fine field for study to any one who cares for such investigations, with every prospect of making real contributions to science. The matter is particularly important just now, because the whole classification of the rodents is in process of revision, and every freshly-discovered character has its value and its influence.

Another branch of anatomy which is full of interest, but has been strangely neglected, relates to the auditory ossicles.* These little bones exhibit great diversities of structure, and are sometimes very remarkable indeed. There seems to be a definite relation between the size and shape of the ossicles and the voice of the animals. Some of the chirping Orthoptera (long-horned grasshoppers), much preyed on by mice, produce such high notes that they are inaudible to some human beings. It may be of advantage to the Orthoptera to be able to call one another in notes so shrill that to some animals they are inaudible, but it may also be advantageous to the mice to have ears well fitted for hearing those high sounds.

It was just stated that the classification of rodents was in process of revision. A Synopsis of the Supergeneric Groups of Rodents, by G. S. Miller and J. W. Gidley, was published in the Journal of the Washington Academy of Sciences, 1918. It is only an outline of a proposed much larger work, but it opens up the whole question of rodent classification in a new way, and is at least of great importance. In the first place, these authors separate the rabbits and pikas or conies from the rodents altogether, as an order Lagomorpha. The true rodents have only two incisors in the upper jaw, the Lagomorphs have four, and hence cannot well be derived from them. The earliest available fossils do not serve to connect the two groups, which have certainly been separated for many millions of years. No one can deny that the Lagomorphs have many distinctive characters, and it is suggested that their resemblance to the true rodents is the result of convergence rather than actual relationship. For our purposes we may still regard the rabbits and pikas as rodents, but the argument for their separation should not be forgotten.

*For details see Bull. Amer. Mus. Nat. History, XXXIII (1914) pp. 347-380; XXXV (1916) pp. 531-532; Zool. Anzeiger, XLIV (1914) pp. 433-440.

Miller and Gidley recognize five superfamilies of rodents, Sciuroidea, Muroidea, Dipodoidea, Bathyergoidea, and Hystricoidea.* The first includes the squirrels, pocket gophers, pocket mice, kangaroo rats, and beavers; the second the mice and rats; the third the jumping mice (*Zapus*) and many exotic genera; the fourth only African animals; the fifth the porcupines, guinea pigs, etc. Thus it appears that the jumping mice and kangaroo rats have quite independently acquired modified hind legs for jumping, as is true of several groups of insects (fleas, grasshoppers, flea-beetles). The Sciuroidea of Colorado are placed in four very distinct families, the Sciuridae or squirrels and their relatives, Geomyidae or pocket gophers, Heteromyidae or pocket mice and kangaroo rats, and the Castoridae or beavers. Miller and Gidley place all our Sciuridae in a single subfamily, but on account of the very different auditory ossicles, and other features, there are good reasons for recognizing a subfamily Marmotinae for the marmots or woodchucks, a group of animals found in the northern regions of both hemispheres. Warren, in his Mammals of Colorado, gives only one kind of woodchuck (*Marmota flaviventer*) as inhabiting Colorado, but since then no less than four races have been recognized within the State. These are *M. flaviventer luteola* of Howell, *M. f. campioni* of Figgins (type from eight miles north of Higho), *M. f. warreni* of Howell (type from Crested Butte) and *M. f. obscura* of Howell. The *luteola* form is northern, extending into Wyoming; *warreni* is western, from Garfield County to Saguache County; *obscura* is southern, being also found in New Mexico, but occurs at very high alttitudes, up to 13,700 feet. The last mentioned is the largest and darkest kind. The typical *M. flaviventer* belongs to Oregon and California, and is not found in Colorado.

Our genera of Sciurinae are quite numerous, and for the most part a characteristically American group. Some are arboreal, others fitted for living on the ground. Perhaps the most distinctive genus is *Cynomys* of Rafinesque, the prairie dogs. The name means dog-mouse. Hollister revised *Cynomys* in 1916 (North American Fauna, No. 40), recognizing four sorts in Colorado. The black-tailed prairie-dog, *Cynomys ludovicianus*, is the common

*They write Sciuroidae, etc., but I have given the more usual termination for superfamily names.

animal found all over the prairies of the eastern part of the state. The name *ludovicianus*, given by Ord in 1815, recalls the former wide extension of Louisiana. The white-tailed prairie-dog, *Cynomys leucurus* of Merriam, is found in Wyoming and Utah, and also the northwest portion of Colorado. It is smaller than the plains species, and the apical part of the tail is white instead of black. The Gunnison prairie-dog (*Cynomys gunnisoni* of Baird) belongs to the mountains of central Colorado, and extends into northern New Mexico. I have seen it in great numbers at Florissant, at an altitude of about 8,000 feet. The terminal half of the tail has a gray center, bordered and tipped with white. The Zuni prairie-dog (*Cynomys gunnisoni zuniensis* of Hollister) has its center of development in New Mexico and Arizona, but has been found at Bedrock, Cortez, and Coventry, Colorado. It differs from true *gunnisoni* by being larger, and the color is more pinkish cinnamon and ochraceous, less buffy and blackish. Hollister proposed a new subgenus (*Leucocrossuromys*) for *C. leucurus* and *gunnisoni*, but I have studied the skulls of all these animals, and do not find any satisfactory basis for such a division.* Possibly something significant may be found in the soft anatomy.

Hollister says: "Prairie-dogs are unquestionably responsible for great annual damage to crops and pasturage. In certain areas the destruction amounts to virtually the entire forage. Crops of grain and cultivated hay are often entirely ruined unless drastic preventive measures are taken. . . . . Among the principal natural enemies of the prairie-dog are the badger, coyote, black-footed ferret, eagle, rough-legged hawk, and raven. . . . Many absurd stories of the joint occupation of dens by prairie-dogs, rattlesnakes, and burrowing owls have been written, but careful observers have found that whatever the relation between these denizens of the plain may be,—and the creatures are often found together in the villages,—it is anything but advantageous to the prairie-dog, and large numbers of its young are destroyed by the unwelcome visitors."

The remaining Sciurinae have comparatively long or very long tails, very bushy in the true squirrels (*Sciurus*). The small squirrel so common in the mountains is called *Sciurus fremonti*,

*See Bull. Amer. Mus. Nat. Hist., XXXIII, p. 367.

after General John C. Fremont, whose expedition obtained the original specimen. A much larger squirrel, the head and body about a foot long, is *Sciurus aberti*, after Col. J. J. Abert, who led an expedition into the southwest. The Abert squirrel, found principally in the foothill country, among the pines, is a very handsome animal, with long tufted ears. The color is variable, so that two races or varieties, *mimus* of Merriam and *ferreus* of True, have been distinguished; the latter originally recorded from Loveland.* Two other races have been found in the States of Chihuahua and Durango, Mexico.

The genus *Citellus* includes the spermophiles (the word meaning seed-lovers) and ground squirrels, according to Warren's Mammals of Colorado; but Miller and Mearns separate the ground squirrels as a genus *Otospermophilus* of Brandt, these being larger animals with longer tails. The auditory ossicles of *Otospermophilus* strongly support its separation from typical (European) *Citellus;* but unfortunately the American *C. elegans*, at least, has ossicles similar to those of the ground squirrels. There is thus some basis for recognizing the genus *Ictidomys* of Allen (type *C. tridecemlineatus*) for the American animals. Miller in his work on the Mammals of Western Europe, says "the limits of the genus *Citellus* are not at present well understood, owing chiefly to the difficulty of comparing the Old World and American forms." However *C. elegans*, the ossicles of which were examined, is placed by Elliot (1901) in the subgenus *Colobotis* of Brandt, which was originally based on *C. fulvus* from southern Russia. It accordingly appears that we may eventually recognize a single genus, or two, or three, for the animals now called *Citellus*. There is a good opportunity for anyone who can obtain specimens, to make a careful study of the whole anatomy, and so decide the matter.

Our most familiar spermophile is the longitudinally striped species, *Citellus* or *Ictidomys tridecemlineatus*. The dark stripes have light spots upon them, so that the whole appearance of the animal is characteristic and unique. This animal exists in Colorado in two distinct races. The larger one, nine to nine and one-

*Dr. Allen wrote to Mr. Warren, that he doubted the distinctness of the race *mimus*.

half inches long, is called *C. t. pallidus* of Allen,* and is common over the eastern part of the State, but also goes to a considerable altitude in the mountains. The other, *C. t. parvus* of Allen, is less than eight inches long, and has been found in Routt, Rio Blanco, Moffat, Garfield, Saguache, and Costilla Counties. W. L. Burnett discusses the economic status of the striped spermophile as follows:** "From an economic standpoint, the striped ground squirrel presents a problem that is somewhat difficult to solve. In some sections of the State it is no doubt very injurious to corn and newly planted seeds of various kinds, while, on the other hand, in other sections it is beneficial by the destruction of grasshoppers and other injurious insects, cutworms, etc. This is especially true throughout the irrigated districts, where in former years grasshoppers have been such a scourge. From our observations, the striped ground squirrel prefers grasshoppers to any other food, and when these insects are abundant it will eat them almost to the exclusion of all other foods."

The other spermophiles are speckled or spotted, but not striped. *C. elegans*, of Kennicott, has been found from about 6,000 to 9,000 feet, in Larimer, Grand, Routt, Rio Blanco, Eagle, and Summit Counties, as recorded by Warren. The tail is less than half the length of the body, and the back is speckled black and yellowish. It is sometimes called the picket-pin gopher, from its habit of sitting upright by its burrow, and thus resembling a stake.

The large spotted spermophile (*C. spilosoma major* of Merriam), originally described from Albuquerque, New Mexico, extends into southeastern Colorado, being common about Pueblo. Warren records a single specimen taken near Denver. The back is cinnamon brown, with whitish spots having black posterior edges; there is a conspicuous white ring around the eye. A related species, *C. obsoletus* of Kennicott, is grayer and duller, the spotting not so extensive, confined to the posterior part of the back. It was described from Nebraska, and in our State has been taken at Wray, Sterling, Greeley, and, as I learn from Mr. Warren, between Briggsdale and Ault.

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*The *C. t. olivaceus* of Allen, reported by Elliot as found by R. T. Young at Boulder, was presumably *pallidus*. True *olivaceus* is found in South Dakota.

**The Striped Ground Squirrels of Colorado, Circular 14, Office of State Entomologist (1914).

The comparatively large rock squirrel, *Otospermophilus grammurus* of Say, was discovered by Long's expedition, the type locality being on the Purgatory River in Las Animas County. The bushy tail is a good distinguishing feature. It is common in rocky places along the eastern side of the front range, and has also been found in the San Luis Valley. Warren says: "Their food is seeds and nuts, acorns, and when living near orchards they are known to do considerable damage to such fruits as apricots, by tearing off the soft parts to get at the stone, from which the seed is extracted and carried away." In western Colorado this is replaced by the race *C. g. utah* of Merriam, with the hind part of the body more reddened, and the tail proportionately a little longer, but Mr. Warren finds it doubtfully separable.

The Antelope-squirrel, *Ammospermophilus leucurus cinnamomeus* of Merriam, was first known from the Painted Desert in Arizona, but also lives in western Colorado, as at Grand Junction, Hotchkiss, and near Montrose. Warren states that the common name is due to the fact that as it runs it elevates the tail over the back, showing the white under surface and giving the appearance of a white rump like an antelope's. There is a white stripe on each side of the back. The remaining two genera are chipmunks, the popular name a corruption of the Ojibway Indian designation. In *Callospermophilus* (meaning beautiful seedlover) the lateral white stripes, placed much as in the Antelope-squirrel, are heavily bordered with black. *C. lateralis* of Say, another discovery of Long's expedition, is the very common big chipmunk of our mountains. Both this and the small chipmunk are very sociable and tame at Long's Peak Inn; a visitor, little versed in zoology, was heard to express the opinion that the big ones were derived from the small, as the result of a liberal diet of peanuts. In Routt County a paler species, *C. wortmani* of Allen, has been taken by Warren. It is an inhabitant of dry country, as its lighter color would suggest.

The small chipmunks, genus *Eutamias*, are common and varied, but the separation of the different kinds requires critical study. The first to be recorded was *E. quadrivittatus* of Say, the four light vittae or stripes alternating with dark ones, there being five of the latter, one in the middle and two on each side. This pattern, varying in distinctness, is found in all the small chip-

munks. Say's animal was discovered on the Arkansas River, about 26 miles below Canon City; it is generally common along the eastern foothills.

Two subspecies have been observed in Colorado, in addition to the typical form. *E. q. hopiensis* of Merriam, discovered in the Painted Desert country of Arizona, extends into the cedar and pinyon region of western Colorado. The ground color of the upper parts is light bright chestnut, the dark stripes not being black. It is another example of a paler form inhabiting a dry region, but quite independently a different pale race, *E. q. animosus* of Warren, has developed in Las Animas and Baca Counties. There is some difference of opinion as to whether *animosus* represents a distinct local race, or merely peculiarly colored individuals; but its appearance is distinct, and it is the kind of animal we might expect in the very dry country it inhabits. However, Mr. Warren writes that he has specimens from bluffs north of Colorado Springs, taken in faded pelage, very like *animosus.*

The Utah chipmunk, *E. dorsalis utahensis* of Merriam, is readily separated by its grayish, washed-out appearance, the dorsal stripes indistinct. It extends into northwestern Colorado, having been taken in the cedar and pinon zone of Routt County.

The above species of *Eutamias* are over 8.25 inches long; but there is another group, that of *E. minimus*, in which the total length ranges from 7.25 to 8.25 inches. The common member of this group is *E. operarius* of Merriam, or the busy chipmunk, formerly supposed to be a subspecies of the Oregon *E. amoenus.* It abounds in the front range, usually at high altitudes; the type specimen was taken by Vernon Bailey at Gold Hill. For a long time it was confused with the species described by Say, but Merriam in 1905 showed that it could be separated. The other members of this group are less likely to be met with. The grayish *E. minimus caryi* of Merriam occurs in Costilla and Saguache Counties; the paler bleached-looking *E. minimus* of Bachman is found in northwestern Colorado; the handsome dark *E. m. consobrinus* of Allen, described from near Salt Lake City, is common in western Colorado. Warren records that in one locality, Yarmony Creek, Eagle County, *E. consobrinus, quadrivittatus,* and *hopiensis* were all taken, though in general they occupy different areas. In a few places the range

of *consobrinus* overlaps that of *operarius*. Anyone who happens to be in these regions of overlapping range should look out for possible hybrids.

The Geomyidae or pocket gophers are digging animals with stout limbs, the cheeks with well-developed external pouches. The tail is short and the ears are small. We have in Colorado three genera, *Thomomys*,* in which the upper incisor teeth are quite smooth or with a minute groove near the inner edge; *Cratogeomys*, in which these teeth have a distinct longitudinal groove, and *Geomys* (the name meaning earth-mouse) in which there are two such grooves. Eight kinds of *Thomomys* have been found in Colorado. The larger forms, over eight and one-half inches long, are *T. fulvus* of Woodhouse, dark, tawny or dull chestnut; *T. fulvus pervagus* of Merriam, larger and paler; *T. perpallius aureus* of Allen, golden buff; *T. perpallidus apache* of Bailey, dark, with hind feet and tip of tail conspicuously white. The last, not mentioned in Warren's book, was found at Arboles and Bayfield. All these have the mammae in four pairs. The smaller forms, less than eight and one-half inches, are *T. ocius* of Merriam, color very pale, mammae normally in seven pairs; *T. fossor* of Allen, dull and dark brown, with rather large ears, mammae in five pairs; *T. talpoides clusius* of Coues, paler than *fossor*, more buffy brown, mammae in six or seven pairs; *T. talpoides agrestis* of Merriam, larger and paler than the last. There is considerable seasonal and individual variation in color which makes the identification of the animals difficult without close study. The common species in the mountains is *T. fossor*, which goes up to and above timber line. *T. clusius* is found along the eastern foothills. Its auditory ossicles are peculiar, the stapes having an enormous bullate foot-plate. The ossicles of the other species of *Thomomys* have not been examined. Of *Cratogeomys* we have only one species, *C. castanops* of Baird, originally based on material from near Las Animas. It is found in the region south of the Arkansas River, and near Lamar. Warren notes that it is darker, larger (length 10½ inches), and heavier built that the Yellow Pocket Gopher, *Geomys lutescens* of Merriam. This latter animal is widely distributed in eastern

*For a full account, see Bailey, North American Fauna, No. 39 (1915). See also Pocket Gophers, by W. L. Burnett, Circular 10, Office of State Entomologist (1914).

Colorado, but is rarely found south of the Arkansas River. Mr. Warren reports that it was taken at Monon, near the Kansas line.

The Heteromyidae also have cheek-pouches, but are distinguished by the hind limbs, which are adapted for jumping. As Miller and Gidley put it, the external form is murine or saltatorial. The typical genus (*Heteromys*) is found in tropical America. We have in Colorado the genera *Perognathus* of Wied, the pocket mice, and *Dipodomys* of Gray (also called *Perodipus*) the kangaroo rats. Warren* cites six kinds of *Perognathus* from Colorado. These animals are readily known from *Dipodomys* by the shorter tail, less than half the total length, and the rooted tuberculate molar teeth. *P. hispidus paradoxus* of Merriam, the Kansas pocket mouse, occurs on the eastern plains. It is much the larger species, the total length over eight inches. *P. fasciatus infraluteus* of Thomas, found at Loveland, is readily known from all the others by the buffy under parts. It is five inches long. *P. flavus* of Baird, widely distributed over the plains, and extending up the Arkansas River to Salida, is the smallest of all, length four and one-half inches or less. It is pale buffy above, lined with black, the under parts white. Another species of the plains region is *P. flavescens* of Merriam, larger than *P. flavus*, but otherwise very similar. In southwestern Colorado may be found the Apache pocket mouse, and according to Warren's latest opinion, the form is not typical Apache, but the darker animal which Osgood named *P. apache melanotis*, from specimens obtained at Casas Grandes in Chihuahua. There is however still another race, *P. apache caryi* of Goldman, discovered eight miles west of Rifle.

The beaver (*Castor canadensis*) has been dealt with so fully in easily accessible works** that it is not necessary to describe its structure and habits here. The Colorado beaver is not the typical *C. canadensis*, but has been referred to the subspecies *frondator* of Mearns, described from Sonora, Mexico. Although beavers occur at various altitudes, they appear to range up and

*The Small Mammals of Colorado. Colorado Mountain Club, 1921.

**Enos Mills, In Beaver World (1913); A. Radclyffe Dugmore, The Romance of the Beaver (no date, but later than 1913). See also E. R. Warren, Some Interesting Beaver Dams in Colorado, Proc. Wash. Acad. Sci. VI (1905); W. P. Taylor, The Status of the Beavers of Western North America, with a Consideration of the Factors in Their Speciation, U. of Calif. Publ. Zoology, XII (1916); F. H. Holden, Osteological Relationships of Three Species of Beavers, U. of Calif. Publ. Zoology, XVII (1917).

down the valleys, and Mr. Alfred Wheeler, who has obtained a great many skins in the region about Boulder, is unable to see any racial difference between the upland and more lowland specimens. The distribution of the races of beaver is peculiar. The *frondator* type, dark red brown, the under fur dusky black, the skull broad, extends from northern Sonora up the Rocky Mountains. In the Rio Grande Valley of New Mexico is a different form, *C. c. mexicanus* of Bailey, of medium size, the colors dull and pale, with very little chestnut at any season. The skull is relatively short, wide and high. The type came from six miles below Ruidoso. In North Dakota is a race *missouriensis* of Bailey, slightly smaller than *canadensis*, and much paler and duller brown; the skull more triangular in outline, not so massive and heavy. It may still be a question whether our beaver is identical with that described from Sonora, as Taylor states that the under fur of true *frondator* is cinnamon-drab or light-drab. Living on the beaver, as an external parasite, is a very remarkable beetle, called *Platypsyllus castoris* of Ritsema. Mr. Ralph Hubbard found specimens on beavers from Marshall and South Boulder Creek. This parasite, constituting a distinct family of Coleoptera, was first found on American beavers in the Zoological Garden at Amsterdam, but it is now known to occur on wild beavers, both in France and America. The European and American beavers have evolved into distinct species, but their more conservative parasite has remained the same. The flattened tail of the beaver, adapted for swimming, is a very peculiar feature. It is interesting to note that the musk-rat, similarly aquatic, has also a flattened tail, but the flattening is in a different (vertical) plane.

The Muroidea, or mice and rats, constitute a very complex group, the classification of which is by no means easy. Miller and Gidley recognize only a single family, the Cricetidae, native in America. The Muridae have been introduced by man. It might be believed that the whole superfamily reached America in comparatively recent times; but there is an extinct Muroid family, Ischyromyidae, in the North American Oligocene. Species of *Ischyromys* have been found fossil in Colorado.* Working on

*See Troxell, Amer. Journ. Science, Feb. 1922.

the auditory ossicles, I have approached the problem of Muroid classification from quite a different angle from that of Miller and Gidley, and now reviewing the subject, would combine their results with mine in a modified arrangement, as follows:

(1) Cricetidae, with subfamilies Cricetinae (Old World forms, with no orbicular apophysis on the malleus, including *Cricetus*, *Cricetulus* and *Phodopus*), Neotominae (wood rats), and Sigmodontinae (white-footed mice and many other genera of North and South America).

(2) Arvicolidae (Microtidae), the voles and musk-rats.

(3) Muridae, the mice and rats introduced from Europe.

Our Neotominae include the genus *Neotoma* of Say and Ord, originally based on an animal from Florida. We have two subgenera; true *Neotoma*, with the tail round, short-haired, smooth and tapering, and *Teonoma* of Gray (an anagram of *Neotoma*) with the tail large and bushy. Although these rats form numerous local races, the range of the species, as generally understood, is remarkable. Thus the original *N. floridana* of Ord, described from Florida, has a race *baileyi* of Merriam, found at Wray, Pueblo and Ft. Lyons in Colorado. It is a large rat, about 14 inches long, dark rusty brownish above in summer, creamy buff or buffy grey in winter.* Goldman remarks** on the great differences between *baileyi* and *floridana*, but says that intermediate races bridge the gap. *N. mexicana* of Baird, described from Mexico, has a race *fallax* of Merriam, discovered at Gold Hill, Colorado, by Denis Gale. This race is widely distributed in our mountains, going down to 4,600 feet. It is about 13 inches long, and is creamy buff or pale grayish above, darker over top of head and back. *N. albigula*, known in various forms from California, Arizona, and Mexico, has a race *warreni* of Merriam, found by Warren in Baca County, and since obtained also at Clayton, New Mexico. Warren describes it as gray above, lightly lined with black; sides and cheeks rather ochraceous; tail black above, white below. The characters of the skull cause it to be grouped with *N. albigula*. *N. micropus* of Baird, described from Tamaulipas,

*Mr. Warren writes that it comes up the Fountain Valley more than 20 miles above Pueblo, and is found in Chico Basin, and at Cedar Point, northwest of Limon.

**Revision of the Wood Rats of the Genus Neotoma. North American Fauna No. 31, (1910).

Mexico, actually goes north unchanged to Monon, Baca County, Colorado. West of its range, all the way from Coahuila to La Junta, Colorado, is a race *canescens* of Allen, smaller, paler, with longer and softer fur. *N. desertorum* of Merriam, a comparatively small pale fulvous animal, extends from the northeast corner of Lower California to a small area in Rio Blanco County, western Colorado. It has also been taken by Warren at Mack, Mesa County. All the above are *Neotoma* proper; the subgenus *Teonoma* includes the mountain rats, or trade rats, the form so abundant in our mountains being *N. cinerea orolestes* of Merriam. Its interesting habits are fully described by Warren in his Mammals of Colorado. *N. c. arizonae* of Merriam, found in Montezuma and Montrose Counties, is smaller and paler, with less bushy tail. *N. c. cinnamomea* of Allen, obtained by Warren in northwestern Moffat County, is paler and redder than *arizonae*.

Our Sigmodontinae include *Reithrodontomys*, with grooved incisors, and tail over half length of body, and the genera *Onychomys* and *Peromyscus*, in which the incisors are smooth. *Onychomys* has the tail less than half length of body, and soles hairy on posterior half; in *Peromyscus* the tail is longer, often more than half length of body, and the soles are naked. All these animals have the size and appearance of mice, not rats, and will not be confused with *Neotoma*. The species of *Reithrodontomys* are called harvest mice; Warren notes that they are smaller than the deer mice, with proportionately longer tails, which are slender, scaly, and thinly haired, while the ears are prominent. *R. albescens* of Cary is found from the sand hills of Nebraska to Loveland, Colorado; *R. montanus* of Baird in the San Luis Valley; *R. megalotis aztecus* of Allen in southwestern Colorado, north to Grand Junction and Rifle; *R. m. dychei* of Allen in eastern Colorado. Of *Onychomys* we have only the species *O. leucogaster* of Wied, but it is represented by two races, of which *O. l. arcticeps* of Rhoads belongs to the eastern part of the State, and *O. l. melanophrys* of Merriam to the west, extending into the Rio Grande Valley in Costilla County. These are called grasshopper mice. The deer mice or white-footed mice, genus *Peromyscus*, are difficult to classify. There is one group with remarkably large ears, including *P. truei* of Shufeldt and *P. nasutus* of Allen, the latter originally described from Estes Park. Another group

has the ears large, but hardly equal to their distance from tip of nose; the tail very long, more than half total length, distinctly pencilled. This includes *P. crinitus auripectus* of Allen, easily recognized by the yellow spot on breast, and *P. boylii rowleyi* of Allen, with no breast spot. The third group has short and rounded ears, and shorter tail, which is not pencilled. This series is divided into the larger (about seven inches long) *P. leucopus tornillo* of Mearns, and the smaller *P. maniculatus*, which has races *rufinus* of Merriam, *nebrascensis* of Coues, and *osgoodi* of Mearns. The *nebraskensis* and *luteus* of Warren's Mammals of Colorado are really *osgoodi* and *nebrascensis* respectively.

The identification of our deer mice is not so difficult if the localities are taken into account. Thus a very large-eared mouse from the eastern foothills, Boulder, Colorado Springs, or Trinidad, will be *nasutus*;* but in the western part of the State it will be *truei*. An ordinary small-eared mouse will almost certainly be one of the *maniculatus* forms. Of these, *rufinus*, according to Warren, is found from the eastern foothills of the Continental Divide, and from west of the Pike's Peak range to the Utah line, and from the north to the south boundary of the State, except that in most of Routt and Rio Blanco, and western Garfield and Mesa Counties it is replaced by the paler, less fulvous *osgoodi*. The range of the latter is practically all of the State not occupied by *rufinus*. The true *nebrascensis* form has taken at Fort Collins, in the *osgoodi* territory. It is a light tawny mouse.

The Arvicolidae include *Ondatra*, the musk rat; *Phenacomys*, the mountain voles; *Evotomys*, the red-backed voles; and *Microtus*, the voles proper. The musk rat, known by its large size and aquatic habits, needs no description. Hollister** recognized two races in Colorado. *O. zibethicus osoyoosensis* of Lord, found in the mountains, is large and dark; *O. z. cinnamominus* of Hollister, belonging to the plains region and foothills, is smaller and pale reddish or brown. But in Boulder County *cinnamominus* goes up to Ward, about 9,200 feet. The original *osoyoosensis* came from Lake Osoyoos, British Columbia. *Phenacomys* is a rare genus, distinguished by the character of its teeth. *P. intermedius* of Merriam (determined by A. B. Howell) was taken by Warren

*P. *nasutus* has also been taken by Warren in the San Luis Valley, near San Acacia.

**A Systematic Synopsis of the Muskrats. North American Fauna No. 32 (1911).

at Lake Moraine, El Paso County and near Buffalo Park, Jackson County; it is a grayish brown mouse five and one-half inches long. It was formerly recorded as *P. orophilus*. *P. preblei* of Merriam, a yellower animal, has been found near Long's Peak and on North Boulder Creek.* Our only *Evotomys* is *E. gapperi galei*, discovered by Denis Gale,** at Ward, and named in 1890 by Merriam. It is known by the chestnut area down the back. We have five kinds of *Microtus* in Colorado, belonging to three different subgenera.*** The introduced Murinae include the house mouse (*Mus musculus* of Linnaeus)**** and the Norway rat (*Rattus norvegicus* of Erxleben). Both are great pests in towns, spreading rapidly over the State since their introduction. Melanic specimens of the Norway rat, taken in Boulder, simulate the black rat, which does not occur in this region. This variety is the *Rattus norvegicus* var *hybridus*, named by Bechstein in 1800. *R. norvegicus* var, *albinus* is the albino form.***** Morgan described a wild variety of *Mus musculus* taken in Colorado, peculiar for its fulvous color; it was perhaps the form named *flavescens* by Fischer in 1872, but it also resembles somewhat the form *azoricus* of Schinz, which Miller regards as a subspecies.

The Dipodoidea include in our fauna the Zapodidae, the jumping mice. They have small internal cheek pouches, long hind limbs adapted for jumping, tail very long, upper incisor teeth grooved. Our species belong to the genus *Zapus* of Coues; the larger and darker one is *Z. princeps* of Allen; the smaller and paler *Z. hudsonius campestris* of Preble. *Z. princeps* is widely distributed, and *campestris* has been found in Larimer, Weld, Arapahoe, Jefferson, and Boulder Counties. These mice are small, but owing to the very long tail, the total length is considerable; eight and three-quarter inches in *campestris*, nine and

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*A. B. Howell (1926) considers that *P. preblei* is not to be separated from *P. intermedius*.

**See Henderson, An Early Colorado Naturalist, Denis Gale; Univ. of Colo. Studies, V. No. 1, (1907). Gale was born in London in 1828, and died in Denver, 1905. His work in Colorado began in 1883. His note books, and his collection of nests and eggs, are in the University of Colorado Museum.

***For details see Bailey, North American Fauna, No. 17. (1900), and Warren's Mammals of Colorado (1910).

****"Inhabits houses and granaries in Europe, Asia and America; follows mankind; eats all kinds of provisions, drinks little; gentle, timid, quick, prolific; devoured by rats, cats, weasels, owls, and hedgehogs; destroyed by elder and hellebore; about 3½ inches long; varies much in color, is said to possess a small electric property when alive." Turton's edition of Linné System of Nature, (1806).

*****See Journ. Comp. Neurology, 22 (1912); p. 71; Amer. Journ. Anatomy, 15 (1913) p. 87.

one-half in *princeps*. The fossil *Paramys delicatior* of Leidy, found in the Eocene of the Huerfano Basin, is referred to the Dipodoidea by Miller and Gidley.

Our representative of the Hystricoidea is the porcupine, *Erethizon epixanthum* of Brandt. It is a common animal in our mountains, well protected from most predatory animals by its quills. Swenk in 1916 described a new subspecies, *E. e. bruneri*, from Scotts Bluff County, Nebraska. Compared with typical (Californian) *E. epixanthum*, it was found to be slightly larger with the hind feet comparatively shorter, the color paler and duller, the under side of the tail largely or wholly brownish yellow, and the skull showing some peculiarities. It appears that this subspecies occurs also in Kansas, Wyoming, and Montana, but whether in Colorado, is not stated. The skull figured by Warren appears to agree well enough with true *epixanthum*.

The Lagomorpha include two very distinct superfamilies, the Leporoidea or rabbits and hares, and the Ochotonoidea or Pikas. The pikas (Ochotona)* occur in North America, northern Asia, and eastern Europe, inhabiting rocky places. There is practically no tail, and the ears have a nearly circular outline. In Colorado we find them at high altitudes, especially above timberline, where their sharp cries seem to come from nowhere in particular, the animals at first not being observed. *O. saxatilis* of Bangs is distributed through the more eastern ranges of Central Colorado, from Wyoming down to Pike's Peak, and westward to the San Juan Range and even into Utah. It also occurs in the Sangre de Cristo Mountains. *O. s. figginsi* of Allen was described from Pagoda Peak. It occupies the mountains west of the central and northern part of the range of *saxatilis*, and is isolated from it by valleys. The colonies of *saxatilis* on the Sangre de Cristo, Pikes Peak, etc., are also isolated, but no distinctive peculiarities have been reported. It is said of *figginsi* that it is smaller, with the color darker and more vinaceous. Nevertheless, the characters of the two races vary, so that individual specimens are intermediate. Howell refers both to *O. princeps*, described from Alberta, as subspecies, but this is perhaps going too far. If we treat *O. saxatilis* as a species, the New Mexico (Pecos Baldy) *incana* will be *O. s. incana*, as Howell

*Howell, Revision of the American Pikas. North American Fauna, No. 47 (1924).

originally (1919) had it, and the form from the Jemez Mountains, New Mexico, described in 1913 by Bailey, will be *O. s. nigrescens.*

Our Leporidae or rabbits consist of the jack-rabbits (*Lepus*) and the cottontails (*Sylvilagus*). The so-called Belgian hare, kept as a domestic animal, belongs to still another genus, and is called *Oryctolagus cuniculus.* This is the common rabbit of England, well known for its habit of burrowing. An American zoologist, finding that the domesticated "Belgian hares" burrowed, published an account of the fact, expressing his surprise at this change of habits in the hare. He was, of course, misled by the name; the true hare is a *Lepus*, allied to the jack-rabbits.

The snowshoe rabbit, *Lepus bairdi*, of Hayden, is able to travel on the soft snow by reason of its large hind feet, with spreading toes. Also, like the ptarmigan, it turns white in winter. It is not so large as the jack-rabbits, and its ears are shorter. It belongs to the higher mountains, but has been known to come as low as 6,500 feet in winter. The white-tailed jack-rabbits, *Lepus townsendii* of Bachman and *L. townsendii campanius* of Hollister, also turn white or pale in the winter. The tail is white above, or with little black, and the profile of the skull is arched. The *townsendii* form belongs to the western part of the State, *campanius* to the eastern. The latter is more yellowish gray in summer, with a broader black patch on tip of ears. The black-tailed jack-rabbit, *L. californicus melanotis* of Mearns, inhabits Colorado east of the mountains. It is really a very distinct species, so that Mearns proposed for it a subgenus *Macrotolagus.* There is a large black patch on the upper surface of the tail, and the animal does not turn white in winter. There is a closely related race *L. californicus texianus* of Waterhouse, which occupies southwestern Colorado. It is much grayer, with longer ears.

The cotton-tails of Colorado are divided into three species, two of these again into a couple of races. In the mountains almost throughout, going up to 10,000 feet or higher, *Sylvilagus nuttallii pinetis* of Allen is a common animal. In southwestern Colorado, the type locality being Coventry, is found *S. auduboni warreni* of Nelson. It ranges from below 5,000 to 8,000 feet, living amongst sage-brush and greasewood. In northwestern Colorado *S. nuttallii grangeri* of Allen takes the place of *pinetis*, being paler, the rufous on legs brighter, the ears somewhat shorter.

In the plains and lowlands east of the mountains *S. auduboni baileyi* of Merriam may be found; but in the same general region, at least to the north, is another species, *S. floridanus similis* of Nelson. The *similis* form may be known from the other by the shorter ears, about two inches from the notch, and the "darker, brighter nape and pectoral band". (Warren.) Fossil Leporidae, found in the White River Oligocene of northeast Colorado, are placed in the genus *Palaeolagus* of Leidy, and have been named *P. haydeni*, Leidy, *P. intermedius* Matthew, *P. turgidus* Cope, and *P. triplex* Cope.

Chapter 3

BIRDS*

The list of Colorado birds is a very long one, owing to the varied conditions within the State, and the fact that stragglers from other regions, east and west, occasionally cross our borders. Professor W. W. Cooke, in 1897, prepared a very interesting summary of the history of Colorado Ornithology, showing how and by whom the additions to the fauna were made known. Pike, in 1810, mentioned the raven, magpie, turkey and "pheasant", the last being the Dusky Grouse. He also referred to a strange new bird, which Aiken and Warren think was the Road Runner. Thomas Say, in his reports on the results of Long's Expedition (1823), recorded eleven species in a definite and scientific manner. Eight of these were described by Say as new to science, and the names are recognized as valid today. These are *Dendragapus obscurus* (Dusky Grouse), *Chloroenas fasciata* (Band-tailed Pigeon), *Tyrannus verticalis* (Arkansas Kingbird), *Carpodacus mexicanus frontalis* (House Finch), *Astragalinus psaltria* (Arkansas Goldfinch), *Cyanospiza amoena* (Lazuli Bunting), *Petrochelidon lunifrons*** (Cliff Swallow) and *Salpinctes obsoletus* (Rock Wren). The remaining three, the robin, magpie and mocking bird, were representative of new races, as these are understood by the analytical ornithologists of today. The Magpie, *Pica pica hudsonica*, was named by Sabine in the very same year (1823) in the Appendix to Franklin's Journal. The Western Mocking-bird, *Mimus polyglottus leucopterus*, was named by Vigors in 1839, and the Western Robin, *Planesticus migratorius propinquus*, by Ridgway in 1877. It was indeed a new world, zoologically speaking, which Say entered a little more than a hundred years ago! After this, there was a very long interval before another bird was added to the Colorado list. Professor S. F. Baird added 19 in 1858 (Pacific Railroad Reports), four in 1859, and one in 1870. But in 1872 Dr. J. A. Allen added no less than 84, and C. E. Aiken, of Colorado Springs,

*See especially W. W. Cooke, The Birds of Colorado, State Agricultural College Bulletin 37 (1897); W. L. Sclater, A History of the Birds of Colorado, 576 pp. (1912); Florence Merriam Bailey, Handbook of Birds of the Western United States, Revised Edition, 590 pp. (1921); Junius Henderson, The Practical Value of Birds, University of Colorado Bulletin, Vol. XIII, No. 4. Aiken and Warren, The Birds of El Paso County, Colorado, Colorado College Publications, Vol. XII, No. 13 (1914).

**It is now claimed (Auk. XXXIV, p. 204) that *P. albifrons* of Rafinesque is an earlier name for this bird.

59. In 1873 Ridgway added 60, in 1876 H. W. Henshaw 14, in 1877 Ridgway 21. For many years following additional records came in, one or a few at a time, but as late as 1897 W. W. Cooke was able to add 19, bringing the list up to 363 species and subspecies. Sclater, in his great work published in 1912, recorded in all 392 kinds of Colorado birds.* Although this is a very large number, it includes no less than 167 which do not breed within the state. Of these, 106 are classified as casual visitors, not belonging to the Colorado fauna in the strict sense. Twenty-eight are winter residents, and 33 merely pass through the State during the spring and fall migrations. This leaves 225 regular breeders, the true Colorado avifauna. Of these only 67 are regular and permanent residents throughout the year; the rest usually or regularly go south in winter. This analysis is derived from Sclater, and would not be materially altered by subsequent publications. Sclater makes a further classification of the 225 regular breeders, according to their breeding places. Thirty-five breed on the plains and up to about 6,000 feet; 80 breed on the plains and in the foothills and parks, up to about 8,000 feet; 33 breed throughout the plains and up into the mountains to 11,500 feet and upwards; 14 breed in the foothills and parks, between 6,000 and 8,000 feet; 24 breed in the mountains, from 6,000 to 11,500 feet; 39 are chiefly confined in the breeding season to the mountains, between 8,000 and 11,500 feet.

Birds maintain a high temperature;** this makes it necessary to have a large amount of food. Henderson cites the following examples: "a young robin in captivity ate 50 to 70 cutworms and earthworms daily from May 21 to June 6, and on June 9, when the bird weighed exactly three ounces, it consumed 165 cutworms, which weighed altogether 5½ ounces, nearly twice the weight of the bird. Another robin on the fourteenth day of its life ate 68 worms, which weighed 41% more than the bird. One snowy owl contained 14 white-footed mice and three meadow mice. A golden eagle in captivity will consume two pounds of fresh meat daily. A Cooper's hawk reared by Judd frequently ate its own weight of food in a day, and another, six weeks old, was observed

*A later estimate increases the number to over 400.

**Wetmore has recently published some very interesting observations on the function of the air-spaces in the bones, in relation to the body temperature. Birds differ from mammals in having no sweat glands.

by Roddy to devour eight English sparrows and a mouse in one day. One flicker stomach contained 5,040 ants and two others contained about 3,000 each. One quail stomach contained 10,000 pigweed seeds, another contained 5,000 pigeon-grass seeds." It can readily be seen from the above why most birds must fly, and many migrate. No sedentary animal could expect to find the amount of food required. The birds resemble mankind, in that their wants have multiplied with their power of supplying them. But also like mankind, they are sometimes penalized for their progress, and when unusual circumstances occur they may be unable to meet them successfully.* In exceptionally hard winters, or after sudden storms, we have a fellow feeling for the birds, and are glad to mitigate their distress by gifts of food. The bird population of any region necessarily changes with the plants, insects and rodents. Thus man's influence, directly and indirectly, controls the abundance or even presence of many birds. One of the most interesting studies to be made today in Colorado concerns the immigration of alien plants and insects, and the effect of these on the birds. The practise of irrigation is changing the face of the country, and this affects nearly all forms of life. The full investigation of these matters is urgently needed at the present time, because after a series of years it will be too late.

Fossil birds are very rare in Colorado, though feathers are not uncommon in the Florissant Miocene and Roan Mountain Eocene.** Two species, a plover and a supposed finch have been described from the Florissant shales. Marsh described a supposed fossil turkey, *Meleagris antiqua*, from the White River Oligocene of Colorado, but Shufeldt considers the material too imperfect for determination. Shufeldt, more recently (1915) described a cormorant, *Phalacrocorax mediterraneus*, from the White River Oligocene at Gerry's Ranch, Colorado. The specimen, part of a carpo-metacarpus, was found by G. B. Grinnell.

It is not practicable within the limits of the present work, to describe or refer to all the Colorado birds. The following

*One such "circumstance" is the Washington Monument at Washington, D. C. The migratory birds, flying at great speed at a height sufficient tc clear all ordinary obstacles, dash themselves against this structure in the night, and perish in great numbers. Our posterity, with more tender conscience in these matters, will probably remove the building, and substitute something much more beautiful and entirely harmless.

**R. W. Shufeldt, Fossil Feathers and Some Heretofore Undescribed Fossil Birds. Journal of Geology, Oct.-Nov. 1913. In this paper Shufeldt describes a fossil bird *Hebe schucherti*, from the Green River Shales of Wyoming. It appears to be related to a group at present known from South America. This should be looked for in the Green River beds of Colorado.

account will however be found to include all those likely to be observed, or of any special interest. They are classified under the several Orders, the characters of which are cited from Sclater, the language somewhat modified.

PYGOPODES

Cutting edge of bill not fringed or toothed (as it is in the ducks); legs placed far behind the middle of the body, so that when the bird is standing its position is more or less erect; toes webbed or lobed. Diving birds, the Grebes (Colymbidae) and Loons (Gaviidae), the former without evident tail feathers. Our common grebe is *Colymbus nigricollis californicus*, the American eared grebe. The Pied-billed Grebe or Hell-diver, *Podilymbus podiceps*, occurs in the summer, and especially during migration. The latter is known by the short, deep, strongly compressed bill, which in summer is crossed by a black band. The head is without a crest, whereas the *Colymbus* has a crested crown in summer plumage. The loons (three species of *Gavia*) are rare migrants or winter visitors in Colorado.

LONGIPENNES

Legs near the middle of the body, anterior toes fully webbed; tarsus shorter than tail. Gulls, terns, and the Parasitic Jaeger or Richardson's Skua (*Stercorarius parasiticus*), the last a rare straggler with us. Of typical gulls (*Larus*) we have seven Colorado species, but only one, the Ring-billed Gull (*Larus delawarensis* of Ord) is at all common. It is known by the yellow or greenish-yellow bill, with a subapical black band; or, in young birds, yellow on basal, black on apical half. Dwight remarks that it is an inland bird in summer, going to the seacoast in winter. *L. californicus*, a closely related bird which very rarely reaches Colorado, has a red spot on the lower mandible. Franklin's Gull (*Larus franklinii* of Richardson)*, with red bill and in summer plumage head black with a white ring around the eye, is common on migration in Kansas and Utah, but rarely crosses Colorado. Two species of terns regularly occur in Colorado; Forster's Tern (*Sterna forsteri* of Nuttall) and the Black Tern (*Chlidonias*** *nigra suri-*

*According to Dwight (1925), Franklin's gull is to be called *Hydrocoloeus pipixcan*. Wagler's *Larus pipixcan* (1831) has a year's priority over Richardson's *Larus franklinii*. *Hydrocoloeus* (Kaup, 1829) is separated from *Larus* by its slender bill and tarsus, small size, presence of a hood and different wing-pattern; but it seems to be a rather weak genus.

**Also called *Hydrochelidon*, but that name is of later date.

namensis of Gmelin). The former is pearl-gray above (mottled when young), and the top of the head is black in summer. The latter is silvery-gray above from the nape, and in summer has the head and nape and under parts black; in winter the black of head and under parts is replaced by white, but the hind part of the crown is dusky gray. The tail is short, not long and forked as in *Sterna*.

STEGANOPODES

Distinguished from all the others by hind and front toes connected by a web. Including the cormorants and pelicans. Two species of cormorant occur as stragglers, but the White Pelican (*Pelecanus erythrorhynchos*) is more frequently seen, and is said to have occasionally bred in former years. The Brown Pelican is represented by a single record, the specimen being preserved in the State Museum in Denver.

ANSERES (ANSERIFORMES)

Cutting edge of bill more or less fringed or toothed; toes fully webbed; newly hatched young entirely covered with down. Family Anatidae, with the subfamilies Merginae (Mergansers), Anatinae (ducks with hind toe not lobed), Fuligulinae (ducks with hind toe lobed, known from the mergansers by the flattened and depressed bill), Anserinae (geese) and Cygninae (swans). A noble assemblage of birds, especially abundant during migration. The American Merganser or Sheldrake (*Mergus americanus* of Cassin) and the Red-breasted Merganser (*Mergus serrator* of Linnaeus) have red or orange legs; but the Hooded Merganser (*Lophodytes cucullatus*) has a black bill and dusky legs. *Lophodytes* is readily known by the high semicircular crest, making the head, seen from the side, appear enormous; but this is more developed in the male than in the female. The species of *Mergus* have a crest on the posterior part of the head in both sexes, but it is short in *M. americanus*. In the male, *M. serrator* has the crest with a patch of reddish-brown streaked with dusky, while in *M. americanus* it is creamy white or pale salmon. The females with white breast, are not so easily separated, but *serrator* is smaller, with more slender bill, and nostril near the base of the bill. These birds are all found

more or less regularly in Colorado, *M. americanus* being comparatively common on migration in April.

The Anatinae, with eight genera, and the Fuligulinae, also with eight genera, are the various kinds of ducks, of which twenty-six species have been found in Colorado. Following the keys of Sclater and Mrs. Florence Merriam Bailey, the genera are separated as follows. *Erismatura* differs from all the others by the tail being more than half the length of the wing, practically without upper coverts, the tail feathers 18. The adult male has the top of the head black. The other Fuligulinae (Sea-ducks), having the hind toe with a flattened membranous lobe, are separated into *Somateria* (American Eider), with the feathering on the lores or forehead extending forward well beyond the posterior border of the nostril, and several genera in which this is not the case. From this point on it is easier to distinguish the ducks (adult males) by the appearance of the head. The Red-head (*Marila americana*) has the whole head and neck bright reddish chestnut, but the Canvas-back (*M. valisineria* of Wilson*) has head and neck rich chestnut brown, dusky on crown and face. The other members of this genus have head and neck greenish or purplish-black; glossed with green in the Scaup Duck (*M. marila*), with purple in the Lesser Scaup Duck (*M. affinis*) and the Ring-necked Duck (*M. collaris*). The last is separated by the dark chestnut collar on neck. The remaining members of the subfamily have conspicuous markings on the head, except the American Scoter (*Oidemia nigra americana*), with dark plumage, but even in this the swollen base of the bill is ornamented with a large yellow and red spot. In the White-winged Scoter (*Oidemia deglandi* of Bonaparte) the black head has a white patch in the region of the eyes, pointed posteriorly. In the Surf Scoter (*O. perspicillata*) the plumage is black, with a triangular white patch on forehead and one on back of head.** The Harlequin Duck (*Histrionicus histrionicus*) is small, with a short bill, head with several white patches, sides of belly bright rufous, wings with steel blue speculum and four white spots. The colors are much duller in the summer

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*A. *vallisneria* of authors. Recent authors place this bird in a distinct genus, *Aristonetta*.

**O. *deglandi* and *O. perspicillata* are referred by some to a distinct genus, *Melanitta*.

than in winter. The form *pacificus* of Brooks has been taken in Colorado.

The Old-squaw (*Harelda hyemalis*) in winter has the head and shoulders white, except for dark patches on sides of head; but in summer is sooty, with white belly, ash-gray face, and white eyelids, the back streaked with chestnut. The Bufflehead (*Charitonetta albeola*) is small, with a round, crested head; the head is shining purple, violet and green, with a very large white area on each side. The Golden-eyes have the head dark with a white patch on the cheek, behind the bill. In the American Golden-eye (*C. clangula americana*) the head is green and the white patch circular; in the Barrow Golden-eye (*C. islandica*) it is blue black, and the spot triangular or crescent-shaped.

The Anatinae or River Ducks are first divided into the Shoveller (*Spatula clypeata*), in which the bill is much expanded toward the end, and the remaining genera in which this is not true. The adult male Shoveller has the head and upper part of neck black, glossed with green, abruptly and sharply contrasting with the white lower part of neck. In the beautiful Wood Duck (*Aix sponsa*) the tail feathers are wide and rounded at end; in the remaining genera they are narrow and pointed at tips. The adult male Wood Duck has the bill marked with black, white, red and yellow; the head and crest purple and green, streaked with white. Of the genera still to be separated, two (*Mareca* and *Querquedula*) have the tail feathers reduced to 14; in the rest there are at least 16. The Baldpate (*Mareca americana*) is easily known in the adult male by the white crown, and the blue bill with white tip. The Blue-winged Teal (*Querquedula discors*) has the under parts spotted in the adult male, and mottled dusky and gray in the adult female; while the Cinnamon Teal (*Q. cyanoptera*) is bright cinnamon red beneath in the male, and mottled dusky and buff in the female. There now remain four genera, among which the Pintail (*Dafila acuta tzitzihoa*) is readily known by the long sharp tail, the head without a crest. There is a white streak extending on to the head from the white throat in the male. The small Green-winged Teal (*Nettion carolinensis*) has a chestnut colored head in the adult male; the wing has a bright green speculum. Much larger ducks are the Gadwall (*Chaulelasmus streperus*), the top of the head with a wide crest in the male, and the

Mallard (*Anas platyrhynchos*) without a crest*. The Mottled Duck (*A. fulvigula maculosa*) has the sexes alike, much resembling the female Mallard. Another species of this genus (*A. rubripes* of Brewster) has been recorded in Condor, vol. 14, p. 151, and it is thought that most of the Colorado records of the Mottled Duck really belong to this form. Farther south, from Albuquerque, New Mexico to El Paso, Texas, is found the *Anas novimexicana* of Huber. It has not been taken in Colorado, but may be expected as a straggler.

The species of Anatinae enumerated occur commonly in Colorado, except the species of *Anas* other than the Mallard, and the Wood-duck; the latter has however been taken a number of times. The Fuligulinae are not so generally common; thus the White-winged Scoter and Surf Scoter are rare winter visitors, the American Scoter is an accidental straggler; the American Eider (*Somateria mollissima dresseri*) has been taken only once; the Ring-necked Duck is very rare; the Old-squaw is an occasional visitor; the Scaup Duck is rather rare; the Harlequin Duck is rare, but apparently breeds in the State. The Ruddy Duck (*Erismatura jamaicensis*) is a summer resident breeding.

The Anserinae or geese are included in three genera, of which *Branta* has the bill and feet black. *Chen* has the bill and feet red, the plumage mainly white; but the young are light gray above, and have dark feet and bill. *Anser* has the bill pink and yellow and the feet yellow, as represented by *A. albifrons gambeli* of Hartlaub, extremely rare in Colorado. Of the three forms of *Chen*, two are only rare stragglers; the third, the Snow-goose (*Chen hyperboreus* of Pallas) is a regular bird of passage. Sclater notes: "Goss states that he has seen thousands of these geese in the fall and early spring in the Arkansas Valley, feeding on the winter wheat, pulling up the young and tender blades with a sudden jerk and doing a great deal of damage." Of our four kinds of *Branta*, two are rare stragglers. The Canada Goose (*Branta*

**Anas platyrhynchos* was also named *A. boschas* by Linnaeus in the same work (Syst. Nat., Ed. 10, 1758). It is thus described in Turton's edition of Linnaeus: "Inhabits Europe, Asia and America, about stagnant waters; 23 inches long; feeds on frogs, snails and almost any filthy substance; builds sometimes near waters, sometimes in trees; lays 10-16 bluish-white eggs. Bill greenish-yellow; head and neck glossy-green; scapulars white with waved brown lines; back brown; vent black-green; breast chestnut; belly grey; wing-spot violet-green, edged above with a black and white line; two middle tail feathers dark green, recurvate. Female reddish-brown spotted with black." The domesticated duck is the same species, and is of course much more variable than the wild bird. The latter does however vary; an albinistic specimen was named var. *albescens* (West Amer. Scientist, April 1889).

canadensis) is the common wild goose; it breeds in the mountains. There is a smaller subspecies, with only 16 (instead of 18 to 20) tail-feathers, known as *B. canadensis hutchinsi* of Richardson. It appears to be uncommon in Colorado, but is perhaps not always distinguished from typical *canadensis*.

Swans are very rare in our State, but the Whistling Swan (*Olor columbianus* of Ord) and the Trumpeter Swan (*O. buccinator* of Richardson) are occasionally observed. The former has, the latter lacks, a yellow spot on the bill in front of the eye.

HERODIONES

These have the lower part of the thighs naked (an adaptation to their wading habits), as in the Paludicolae and Limicolae. But they differ by having the hind toe long, and inserted nearly at a level with the others, and the loreal or orbital regions, or both, naked. We have the families Plataleidae (for the rare Roseate Spoonbill, *Ajaja ajaja*), Ibididae or Threskiornithidae (Ibises), Ciconiidae (the stork family, including the so-called Wood Ibis, *Mycteria americana*, which has occurred as a straggler) and Ardeidae (herons, egrets and bitterns). Of the four species of Ibis, the white *Guara alba* and the scarlet *G. rubra* are extremely rare stragglers. The Glossy Ibis (*Plegadis autumnalis*) is also an accidental visitor, but the White-faced Glossy Ibis (*P. guarauna*) is a summer resident, breeding up to about 7,500 feet. It has the feathers surrounding the face white. All these species of ibis were described by Linnaeus in the eighteenth century. The Ardeidae, with long and straight bill, are numerous in Colorado. The two genera of bitterns have the tail feathers reduced to ten, short and soft. The American Bittern (*Botaurus lentiginosus* of Montagu) has conspicuously striped plumage; it is rather common during the summer months. It was originally described by Col. Montagu in 1813 as a new British bird, an individual having somehow turned up in Dorsetshire. The Least Bittern, (*Ixobrychus exilis*) is only about half as large, and has the back black or brown. It is a rare summer resident. The Black-crowned Night Heron (*Nycticorax nycticorax naevius*) and the Yellow-crowned Night Heron (*N. violaceus*) have a comparatively short and stout bill, and in breeding plumage a few very long white plumes from the back of the head. In the former the crown is black, in the

latter creamy white. The black-crowned bird is not rare; the other only occurs accidentally. The young Black-crowned Night Heron is quite unlike the adult, being reddish brown streaked with white. The remaining herons are classified by some authors in six genera, but others treat them as subgenera of *Ardea*. We have first of all those with entirely white plumage; the egret (*A. egretta*)*, with long plumes on the back only; the Snowy Egret (*Ardea* or *Egretta candidissima***) with long plumes on crown, neck and back. For the first we have only two records, but the second has been observed on numerous occasions. The Little Blue Heron (*Ardea caerulea*)***, which has been recorded from Montrose (Condor, vol. 14, p. 151) is for the most part slaty blue, but sometimes white. It has the head and neck chestnut or maroon, and has plumes on the crown. The remaining three herons are easily separated by size. The Great Blue Heron (*Ardea herodias treganzai* of Court) is about 45 inches long; the upper parts are bluish gray. It is a common Colorado bird. The Reddish Egret (*A. rufescens*)****, for which there is only one Colorado record, is 31 inches long. The Green Heron (*A. virescens*),***** also recorded only once, is about 12 inches long.

PALUDICOLAE (GRUIFORMES)

"If the wing is over 15 inches, hind toe elevated above the others; if under ten inches, hind toe on a level with the others" (Sclater). The larger birds referred to are the Cranes; the others are the Rails and Coots. Our cranes (Gruidae) include three species, the Whooping Crane (*Grus americana*), the Little Brown Crane (*Grus canadensis*) and the Sandhill Crane (*Grus c. mexicana*). These birds present some resemblance to the storks, but it is superficial, and does not extend to their anatomy. The first mentioned has the plumage white, with black primaries. The second is much smaller, about 36 inches long, and has the plumage slaty gray. The third is like the second but larger, about 48 inches long. The Whooping Crane has been considered to belong to a

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*Also called *Casmerodius egretta.*

**It is held by some that this should be called by Molina's name *E. thula*, but the A. O. U. Committee has not accepted the change.

***Also called *Florida caerulea.*

****Also called *Dichromanassa rufescens.*

*****Also called *Butorides virescens.*

distinct genus, *Limnogeranus*. The Rallidae include the Rails and Coots, with six genera in Colorado. The Virginia (*Rallus virginianus*) is easily known from the Carolina Rail or Sora (*Porzana carolina*) by the very much larger bill; the latter has a short and compressed bill, and in the adult the face is black. Both are regular summer residents in Colorado. The Coot (*Fulica americana*) is a very dark bird with white or whitish bill, and the toes with scalloped lobes. It is common during the summer. The remaining Rallidae, *Creciscus jamaicensis*, *Gallinula chloropus cachinnans*, and *Ionornis martinicus*, are only excessively rare casual visitors. The last was once taken at Florence (Condor, vol. 14, p. 151).*

LIMICOLAE

"Wing never over 15 inches; hind toe when present short and elevated" (Sclater). Sclater treats this group as an order; Knowlton and others make it a suborder of the heterogeneous Charadriiformes, which also includes the gulls and pigeons.** The Limicolae are characteristically long-legged birds, often found by the sea or in marshes. They include the snipes, woodcocks, sandpipers and plovers. Our very numerous species are referred to the families Phalaropodidae (phalaropes, with expanded toes), Recurvirostridae (avocets and stilts), Scolopacidae (snipes, woodcocks and sandpipers), Charadriidae (plovers) and Arenariidae (Ruddy Turnstone, which is a rare straggler). Our two species of phalaropes occur as migrants; the Northern Phalarope (*Lobipes lobatus*) has the toes with scalloped margins, approaching the condition of the coot. In Wilson's Phalarope (*Steganopus tricolor*) this is not the case. The Avocet (*Recurvirostra americana*) is readily known by the long upturned bill, though this is not so evident in the young. It is locally abundant in Colorado. Much less frequent is the Black-necked Stilt (*Himantopus mexicanus*), with extremely long pinkish legs, body greenish-black above and white beneath, bill long and straight. The Scolopacidae are a

*See also W. W. Cooke, Distribution and Migration of North America Rails and their Allies. U. S. Dept. Agriculture Bull., 128.

**In my Zoology (1920), I followed Knowlton's arrangement of Orders, which is based on the researches of many authors, and has the advantage of reducing the number of major groups. But here I follow Sclater, who treats several of the Orders in a more restricted sense, a proceeding which gives us more coherent and apparently natural subdivisions. There is no essential difference of opinion as to the facts, but only as to the manner of representing them.

complex assemblage, but the curlews will be known by the long bill turned downward at the end. Our form is the Long-billed Curlew (*Numenius americanus*), a large bird, 20 inches or more in length, with dagger-like markings. The smaller Hudsonian Curlew (*Phoeopus hudsonicus*) is only rarely seen. The Eskimo Curlew (*Mesoscolopax borealis*) must certainly have ranged into Colorado at one time, but there are no records. It is now almost extinct.* It is a comparatively small bird, with little curved bill.

The Sanderling (*Crocethia alba* of Pallas)** is known by the absence of the hind toe; it is a rare visitor. The remaining 14 genera, possessing a hind toe, include 19 species, but of these *Tryngites subrupicollis* (see Condor, vol. 14. p. 151) and *Pelidna alpina sakhalina* are merely stragglers from the regions they normally inhabit. The snipe group is peculiar for having the ear under the eye (under the anterior corner in the woodcock). In the American Woodcock (*Philohela minor*)*** the three outer quill feathers are abruptly narrowed apically. The Wilson Snipe or Jack Snipe (*Gallinago delicata*) has 16 tail feathers and streaky plumage, while the Long-billed Dowitcher (*Limnodromus scolopaceus*) has 12 tail feathers and mottled plumage. The latter bird was named by Say; he obtained it on Long's Expedition near the present city of Council Bluffs, Iowa.

The sandpiper group has the ears in the ordinary position, behind the eyes. The two genera, *Pisobia* and *Pelidna*, have the toes wholly without webbing. In the White-rumped Sandpiper (*Pisobia fuscicollis*) the upper tail coverts are white with slight streaking; but in the other three kinds of *Pisobia* they are blackish. These latter will be known by their size; the Pectoral Sandpiper (*P. maculata*) about eight to nine and one-half inches long, the Baird Sandpiper (*P. bairdi* of Coues) about seven to seven and one-half inches, the Least Sandpiper (*P. minutilla*) about five to six and three quarters.

There still remains a series of genera in which the toes are more or less webbed. In the Upland Plover or Bartramian Sand-

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*M. H. Swenk, The Eskimo Curlew and Its Disappearance, Smithsonian Report for 1915-(1916).

**Peter Simon Pallas, 1741-1811, was a German Naturalist who went to Russia at the request of the Empress Catherine II, to investigate the flora and fauna of the Russian dominions. This he did most effectively, discovering and describing great numbers of plants, birds, etc., taking all animated nature for his province.

***Also called *Rubicola minor*.

piper (*Bartramia longicauda*) the tail is long (three inches), reaching beyond the tips of the folded wings; the toes are webbed only between the outer and middle ones. This bird inhabits the open prairie, and is not attracted to bodies of water like the other sandpipers. The genera *Micropalama* and *Ereunetes* are readily known from all which follow by the absence of barring on the tail; the bill is more or less widened at the tip. The Stilt Sandpiper (*Micropalama himantopus*) is about eight and one-half inches long, with long and slender bill. The Semipalmated Sandpiper (*Ereunetes pusillus*) and the Western Sandpiper (*E. mauri* or *occidentalis*) are smaller birds, the latter distinguished by the longer bill (.88-inch in male, 1.05-inch in female). The latter is extremely rare. Among the birds with barred tails, *Tringa* (length eight and one half inches) and *Actitis* (length six and three-fourths inches) are known by their small size. The Western Solitary Sandpiper (*Tringa solitaria cinnamomea*) has the under wing-coverts banded, and the lower breast entirely white. The Spotted Sandpiper (*Actitis macularia*) has the under wing-coverts white and the abdomen spotted. Among the larger barred-tailed species, the two kinds of *Totanus* are easily known by the yellow legs. The Greater Yellow-legs (*T. melanoleucus*) is 13 inches long; the Yellow-legs (*T. flavipes*) only about nine and one fourth inches.

The Western Willet (*Charadrius semipalmatus inornatus*), the type locality of which is in Larimer County, has a white patch on the wing and at the base of the tail. The Marbled Godwit (*Limosa fedoa*) has no such white patches.

The Charadriidae or plovers have the bill at most the length of the head, and ending in a hard convex swelling called the dertrum. The Black-bellied Plover (*Squatarola squatarola cynosurae* of Thayer and Bangs) is different from all the others in having a small hind toe. It is uncommon in Colorado, occurring in the region just east of the front range. There is a good deal of confusion about the nomenclature of the other genera, both as to the limits of the genera and the names to be applied to them. In the Golden Plover (*Pluvialis dominicus*), the back is spotted, and the belly is black in summer, grayish in winter. It occurs occasionally during migration. The other species, formerly all referred to *Ægialitis*, have the upper parts plain, and the belly

white. The Mountain Plover (*Podasocys* or *Eupoda montana* of J. K. Townsend) has no black patches or bands on the breast; the toes are very short. It is or was common on the plains, and goes up to about 8,000 feet in the mountains. The Killdeer (*Oxyechus vociferus*), well named by Linnaeus, is well known to all who have been about the State. It has a habit of running in the road ahead of travellers, or did so until the latter took to driving furiously in automobiles. The common name is an attempt to imitate its cry, which has been rendered kill-dee', kill-dee', by Vernon Bailey. It is a pretty bird, the head and chest marked with black and white. The Semipalmated Plover, *Ægialitis* or *Charadrius semipalmatus*, is much smaller, and has only one black band across the upper part of the breast, the killdeer having two.

It is customary to classify all the above birds as Water Birds, as against the Orders of Land Birds which follow. In a general way the distinction is valid, but there are exceptions. Thus among the "Land Birds" the Dipper has aquatic habits, and the "Water Bird" *Bartramia* is thoroughly terrestrial. The Orders of Land Birds are distinguished by easily recognizable characters. If the bill is strongly hooked, and the toes are two in front and two behind, the bird is a parrot (Psittaci). The hawks and owls, also with hooked bill, have the toes three in front and one behind. They were formerly classed together under the name Raptores, but are now separated into Accipitres (hawks and eagles) and Striges (owls), as they have important anatomical differences. The pigeons (Columbae) do not have a strongly hooked bill, but they agree with the orders just listed, and differ from those which follow, in having a cere of soft, swollen skin at the base of the mandibles. Structurally, the pigeons are more related to some of the water birds than to the other land birds, and the owls are more related to the kingfishers and humming-birds than to the hawks.

Of the orders without a cere, the Gallinae (grouse, pheasants, domestic fowl, etc.) are known by the hind toe being comparatively small and placed higher than the others, at least in the Colorado species. The Macrochires appear to us composite, including the goatsuckers, whip-poor-wills and swifts, with short broad bills; and the humming-birds, with long slender bills.* The

*Shufeldt, as long ago as 1889, showed that the osteology of the swifts was exceedingly different from that of the humming-birds.

Pici or woodpeckers have the toes two in front and two behind, or there may be only three toes. The Coccyges (cuckoos, road-runner and kingfishers) never have stiff pointed tail feathers like those of the woodpeckers; the toes are two in front and two behind (cuckoos), or three in front and one behind, the middle and outer ones connected for half their length (kingfishers). The remaining birds constitute the enormous order Passeres, the perching birds, with toes three in front and one behind, the middle and outer toes not united. As a matter of fact nearly everyone knows these ordinal groups and their major subdivisions at sight, and technical details are not necessary for indentification.

GALLINAE

The family Meleagridae (turkeys) is known at once by the naked head and neck. Merriam's turkey (*Meleagris gallopavo merriami* of Nelson) was common in the days of Pike (1806), but is now scarce and in danger of extinction.* The name gallopavo means chicken-peacock, or peacock-hen. The quails (Odontophoridae) have the tarsus bare; in the grouse (Tetraonidae) it is more or less feathered. The Bob-white (*Colinus virginianus*), with no distinct crest on the head, is found in Eastern Colorado, having spread with human occupation, and in many places introduced by man. Lincoln has described a distinct race (*C. v. taylori*) from Yuma County. The beautiful Scaled Quail (*Callipepla squamata pallida*) has a high white-tipped crest on the head, and the feathers of the neck and breast are dark-edged, giving the appearance of scales. It inhabits the country south of the Arkansas River, but has spread north and east in recent years. The genus *Lophortyx* is known by the slender upright, curved, club-shaped crest; it includes the introduced California Quail (*Lophortyx californica*) and the Gambel Quail (*L. gambeli*). The former has the under side of the body "scaled", after the fashion of *Callipepla*; in the latter this is not the case. The University of Colorado Museum has a pair of Gambel's Quail taken by A. T. Wheeler at Montrose in 1905, and Mearns stated that a specimen of the race *L. g. sanus* was taken at Olathe in Montrose County.

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*M. *gallopavo intermedia* of Sennett, orginally described from Texas, is reported by Hutton, Bull. Colo. Game and Fish Assn., IV (1924) No. 4, p. 4.

James' Sharp-tailed Grouse. *Pediocetes phasianellus jamesi* Lincoln from the type locality (Castle Rock). Specimens in Colorado Museum of Natural History

Color Mus. Photo

The Tetraonidae of Colorado are divided into six genera. *Lagopus leucurus*, the Ptarmigan, is easily known by the densely feathered tarsus and toes, an adaptation for walking on snow. It inhabits the high mountains, and turns white in winter. Our form was named *L. leucurus altipetens* by Osgood. The Gray Ruffled Grouse (*Bonasa umbellus umbelloides* of Douglas) is known by the black ruff at base of neck; it is very rare with us.* The long and attenuated tail distinguishes the large Sage-hen (*Centrocercus urophasianus*); the specific name, given by Bonaparte, means tail-pheasant. It is found in the region of the sage-brush (*Artemisia*)**. In the Dusky Grouse (*Dendragapus obscurus*) the tail is long but not attenuated. This is the familiar grouse of our mountains, found among the timber. The Prairie Chicken (*Tympanuchus americanus*) has a slightly crested head, and the neck with two long tufts of feathers over the bare yellow distensible tympanum or wattle. It is a bird of the Mississippi Valley, gradually extending westward owing to conditions created by human occupation. The Sharp-tailed Grouse (*Pediocoetes*) have a naked patch over the eye with yellow papillae, the short tail has 18 strongly graduated feathers. The Prairie Sharp-tailed Grouse (*P. phasianellus campestris*) belongs to the prairie region east of the mountains, but is now scarce. In Western Colorado it appears to be replaced by the more buffy and grayish *P. p. columbianus*, which was originally described from the plains of the Columbia River drainage. Lincoln has recently described a new race, *P. p. jamesi*, the type from Castle Rock.

It is now necessary to add still another family to this group, the Old World Phasianidae, represented by the Ring-necked Pheasant (*Phasianus torquatus*), which has become common where it has been introduced.

COLUMBAE

The Mourning Dove (*Zenaidura macrura marginella*), with wedge-shaped tail, is one of our commonest birds, often seen sitting on fence posts. The Band-tailed Pigeon (*Chloroenas fasciata*)

*Mr. Warren writes that he doubts the published records; Mr. F. Lincoln investigated the matter, and could not find any satisfactory evidence. Professor Henderson agrees with Mr. Warren.

**Sclater, and many other non-botanical authors, insist on spelling this word Artemesia, as if they had never seen the name Artemis.

is a larger bird, with a rounded tail. It was discovered by Say on Plum Creek, near Castle Rock. The White-winged Dove (*Melopelia asiatica mearnsi*) is recorded as an accidental visitor. In spite of the specific name, it is a species of the warmer parts of America.

ACCIPITRES

The Cathartidae are represented by the Turkey Vulture (*Cathartes aura septentrionalis* of Wied), easily known by the red naked head and neck. It is a common bird, but not obtrusive as it is in some places where it is protected as a scavenger. A single specimen of the Black Vulture (*Coragyps urubu*) was obtained in Boulder, and is in the University Museum. The Pandionidae have a single representative in the American Osprey (*Pandion haliaetus carolinensis*), which is not uncommon. It has the outer toe reversible, and the claws all approximately the same length, characters which separate it from all the Falconidae. It feeds entirely on fish. The Falconidae* are well represented with ten genera. Two of these are large, the wing over 17 inches, and are eagles. Although the Golden Eagle (*Aquila chrysaetos*) was described by Linnaeus from Sweden, and extends thence right across Asia and America, it has not split up into subspecies in this long range. The Bald Eagle or White-headed Eagle (*Haliaetus leucocephalus*) extends across the United States, but there is a distinct subspecies in the northwest. In Colorado, the Golden Eagle is the commoner of the two.

The genus *Falco* stands apart by the prominent tooth-like projection on the cutting edge of the upper mandible, and is also peculiar for the circular nostrils, with a central bony tubercle. Our four species have been placed by recent authors in as many genera. The larger birds, with only the outer primary feather emarginate, are the Prairie Falcon (*F.* or *Hierofalco mexicanus*) and the Duck Hawk (*F.* or *Rhynchodon peregrinus anatum*). The former is clay brown above, below with dusky linear spots; the latter slaty-blue above when adult, but blackish, edged with tawny, when young. The smaller forms (wing under 10 inches)** have

*Sometimes divided into two families, Falconidae and Buteonidae. On this basis, *Falco* in the broad sense, alone represents the Falconidae in our fauna.

**The wing in birds is measured from the front of the bend of the wrist joint to the tip of the longest feather.

the two outer primaries emarginate. If the head has on each side a pair of vertical black stripes, the bird is the American Sparrow-hawk (*F.* or *Cerchneis sparverius*). This is a very common bird, feeding principally on insects; specimens from the western part of the State are paler, and are referred to a subspecies *phalaena*. There remains a species without the black stripes on sides of face, the adult male above bluish-slate, most of the feathers with a black central line. This is the Pigeon Hawk (*Falco* or *Tinnunculus columbarius*), usually observed on migration. In a few places in the mountains Richardson's Pigeon Hawk (*F. c. richardsoni*) has been observed; it has the outer webs of the primaries spotted with white.

The Buteonidae or Buteoninae include the remaining genera, in which the edge of the bill is not toothed, though it may be festooned. If the tibia and tarsus are about equal, we have *Accipiter* or *Astur*, the former with the middle toe very long. The Goshawk (*Astur atricapillus*) is slaty-blue above in the adult male, with the crown almost black; but the young bird, more often seen in Colorado, is dark brown above, the feathers of the head and back largely edged with tawny, while there is an indistinct white collar across the back of the neck. It is nearly always found in winter in our State. A western subspecies (*A. a. striatulus*), with darker colors, is reported from Garfield County. The two species of *Accipiter* are among our common birds; the larger (wing 9 to 11 inches), with rounded tail, is Cooper's Hawk (*A. cooperi*); the smaller (wing six to eight and one-half inches), with the tail even or slightly notched, is the Sharp-shinned Hawk (*A. velox*). Cooper's Hawk is destructive to poultry, and is the one species which may be regarded with disfavor. The next five genera have the tibia longer than the tarsus. The kites have only the outer two primaries emarginate on the inner web. The two species recorded, representing the genera *Elanoides* and *Ictinia*, are rare stragglers. In *Circus* and *Buteo* three to five of the outer primaries are emarginate. The Marsh Hawk (*Circus cyaneus hudsonius*) has a rather owl-like face, more or less surrounded by a ruff; the wing is 13½ inches in the male, 15 inches the female. It is very common in Colorado, particularly on the plains. *Buteo*, with which *Archibuteo* may be included as a subgenus, is represented by four species, these including the common large hawks often seen flying

overhead. The tarsus is feathered to the toes in the American Rough-legged Hawk (*B.* or *Archibuteo lagopus sancti-johannis*) and in the Ferruginous Rough-leg (*B.* or *A. ferrugineus*). Both are very useful, feeding on small rodents. In the normal phase the belly has a black patch in the former, lacking in the latter, which has thighs rufous with black cross-bands. Both are sometimes melanistic, the plumage black or sooty-black, but then the American Rough-leg has a white forehead. The tarsus is half feathered, with scutes in front only, in the Red-tailed Hawk (*B. borealis calurus*) and Swainson's Hawk (*B. swainsoni*). In the former the four outer primaries are emarginate on the inner web, the latter only three. It is necessary to pay attention to these characters, for the plumage of the birds varies greatly in color. The Red-tail has the tail rich rufous, with a subterminal black band; but in the young the tail has ten or twelve dusky black bars and a white tip. A pale race (*B. b. krideri*) occurs in Eastern Colorado, and a single specimen supposed to be from El Paso County was referred to the race *harlani* of Audubon.*

STRIGES

The owls, flying by night, excepting *Speotyto*, are not likely to be confused with any other birds. The Tytonidae, with the claw of the middle toe serrate on inner edge, are represented only by the American Barn-owl, *Tyto alba pratincola*, a rare bird with us. The generic name *Aluco*, based on the same species, was earlier used for a mollusc, so *Tyto* (1890) is available. The rest of the owls fall in Strigidae, with no serration on claw of middle toe, which is always longer than the inner one. The ear-tufts are present in three genera, *Bubo*, *Asio* and *Otus*, but absent in the others. The first of these genera consists of large owls, the wing over 14 inches; in the second the wing is 10 to 12 inches, and the toes are feathered to the claws; in *Otus* the wing is under eight inches, and the toes are bristly or naked. These eared owls constitute a prominent and important part of our avifauna, and some of them show variations in plumage which have proved perplexing. The Western Horned Owl (*Bubo virginianus occidentalis* of Stone)

*Mr. Warren writes that Aiken bought the skin from Borcherdt in Denver, when he first came to Colorado, and the locality is wholly uncertain. The specimen appears to have been lost. This record is therefore of no value, but Lincoln in 1920 recorded *harlani* from Littleton.

is rather common; another race, *B. v. lagophonus* of Oberholser, has been taken as a straggler. *Asio* includes two common species, the American Long-eared Owl (*A. otus wilsonianus*) and the Short-eared Owl (*A. flammeus*), the latter a winter visitor. Their vernacular names indicate the difference, the ear-tufts of *A. flammeus* are inconspicuous. Of *Otus* we have the Rocky Mountain Screech Owl (*Otus asio maxwelliae*) and the darker and more heavily streaked race of the same species, *O. a. aikeni*, each named after a famous Colorado collector of birds. The type locality of the first is in Boulder County, of the second in El Paso County. It is singular that the Screech Owl should have one race north of the Arkansas-Platte divide, and another south of it, but there is some indication that the birds do not always keep to their own territory. The Flammulated Screech Owl (*Otus flammeolus*) is quite a rare bird, smaller than the forms of *O. asio*, and with shorter ear-tufts and bare unfeathered toes.

The owls without ear-tufts are placed in five genera. The small (wing under four inches) Pygmy Owl (*Glaucidium gnoma pinicola* (represents a southern type coming north and becoming modified accordingly. It is rarely found, usually among pine trees. The plumage is mainly white (especially in the male) in the large Snowy Owl, *Nyctea nyctea*. It breeds in the arctic regions, and comes south in winter. Not so large (wing 12 to 13¼ inches; 15½ to over 17 in *Nyctea*) are the species of *Strix*, both of which are rare stragglers. Considerably smaller (wing six to eight inches) are the genera *Cryptoglaux* and *Speotyto*, the toes densely feathered in the former, merely bristly in the latter. The Saw-Whet Owl (*Cryptoglaux acadica*) is a regular resident. It has a black bill, but the very rare *C. funerea richardsoni* is larger and has a yellow bill. The Burrowing Owl (*Speotyto cunicularia hypogaea*) is the well known inhabitant of the prairie-dog towns, living on the open plains, and of partially diurnal habits. It appears that usually, at any rate, it does not burrow for itself, but occupies deserted holes.

PSITTACI

The beautiful Carolina Paroquet (*Conuropsis carolinensis*) enters the Colorado list on the strength of a statement by Berthoud, that in the early sixties of the last century he saw specimens on

several occasions, at Golden, near Denver, on the Little Thompson and near Fort Lyon. We may suppose that stray flocks occasionally entered Colorado in former times, but they will never do so again. The bird used to be referred to the tropical genus *Conurus*, which it much resembles, but in 1891 Count Salvadori made it the type of a new genus. Mounted specimens may be seen in the Colorado Museum of Natural History.

COCCYGES

The Road-runner (*Geococcyx californianus*), with crested head and long tail, body plumage above metallic bronze, is such an extraordinary bird that once seen, it can never be confused with any other. It is placed with the cuckoos (Cuculidae), but in a peculiar family (Neomorphinae) which is also represented in Borneo and Sumatra. It lives on the ground, running rapidly, feeding on insects, reptiles and young birds. Of true cuckoos, if we may so designate the American species, which do not parasitize other birds, we have three forms. The Black-billed Cuckoo (*Coccyzus erythropthalmus*), with the lower mandible black, and the outer tail feathers only obscurely white at the end, is very rare. The Yellow-billed Cuckoo (*C. americanus*), with the lower mandible mainly yellow, and outer tail feathers strongly tipped with white, is somewhat less rare, but not often seen. Some of the specimens appear to belong to the larger western race *C. a. occidentalis* of Ridgway. Our only kingfisher (Alcedinidae) is the well known Belted Kingfisher, *Ceryle alcyon*. It is sometimes seen on the University of Colorado Campus.

PICI

The woodpeckers are remarkable for the very long extensile tongue. Fifteen species and races have been reported from Colorado, referred to eight genera. Two of these genera, *Centrurus* and *Phlocotomus*, are only represented by casual wanderers, but others are well established or common. The Red-headed Woodpecker (*Melanerpes erythrocephalus*), with its bright red head and black and white wings, is easily recognized. Everyone knows the mottled flickers (*Colaptes*), with black crescent on breast, and the colored shafts of the large feathers showing as they fly. Our

common bird is the Red-shafted Flicker (*C. cafer collaris*), which feeds on ants, but also on fruits. I have seen it eating the berries of the Virginia Creeper in Boulder. Sometimes a strange noise is heard on the University of Colorado Campus, due to the drumming of a flicker on the iron roof of the library. The bird certainly appears to enjoy the sound, as we enjoy music. The specific name "cafer" (caffer) was given under the mistaken idea that the original specimen came from South Africa. The Yellow-shafted Flicker (*C. auratus luteus*) occasionally occurs in Eastern Colorado, and intermediates, assumed to be hybrids, are not rare. A third form, described by Ridgway in 1911 as *C. a. borealis*, occurs only as a casual visitor. Another easily recognized species is the Lewis Woodpecker (*Asyndesmus lewisi*), the name of which commemorates the famous explorer of the west.* The body is greenish-black above, including the wings, but the under side is pinkish-red. It is a common bird in the foothills, as at Boulder.

The Three-toed Woodpecker (*Picoides americanus dorsalis*) is known in the hand by the three toes, but when at large it may be recognized by the black and white colors, wholly without red. The male has a yellow patch on the crown, but in the female this is wanting. Sclater says it rarely comes below 7,000 feet, but on January 1, 1925, I saw one in Boulder, busily pecking on an apple tree. The weather had been unusually cold. The genus *Sphyrapicus* is known by the yellow of the under parts, the colors otherwise being black and white, with red markings on the head. In the Red-naped Sapsucker (*S. varius nuchalis*) the back is black, spotted with white and yellowish; the crown, nape and throat are red. Williamson's Sapsucker (*S. thyroideus*) has the back all black in the male, cross-banded black and white in the female. The red is confined to the throat, and nearly or quite lacking in the female. This difference in the sexes is unique among our woodpeckers. The species of *Dryobates* are wholly without yellow, and the red is confined to the crown. In the Texan Woodpecker (*D. scalaris cactophilus* of Oberholser) the back has numerous cross-bars of black and white; it occurs in the southeastern part of the State. There is another race of this species (*D. s. symplec-*

*In our local flora, we have blue flax, *Linum lewisii*, and the bitter root, *Lewisia*, also named after Meriwether Lewis. An analysis of the zoological results of the Lewis and Clark expedition is given by Coues in Bull. U. S. Geol. and Geog. Surv. Terr., Feb. 1876.

tus) which has been taken in St. Charles Canon, Pueblo County. The two remaining species are very much alike, the back black, with an elongated white patch in the middle. The outer tail feathers are barred with black, and the wing measures only about four inches, in Batchelder's Woodpecker (*D. pubescens homorus*); while the outer tail feathers are white, and the wing is over four and one-half inches, in the Hairy Woodpecker (*D. villosus*). Nearly all the specimens of the latter species found in Colorado belong to the subspecies *D. villosus monticola* of Anthony, the type locality of which is in Boulder County. It is larger than the eastern or typical race, and has no spots on the wing coverts.

MACROCHIRES

The Caprimulgidae have recently been divided, on structural grounds, into two families, the night-hawks being separated as a family Chordeilidae. The Western Night-hawk (*Chordeiles minor henryi*) is a well known bird, regarded as a sign that spring has surely come. Oberholser has recently separated a race *howelli*, found in our region. The true Caprimulgidae, with long conspicuous rictal bristles below the mouth, include the Poor-will (*Phalaenoptilus nuttalli* of Audubon), which is not uncommon in summer. The paler form *nitidus* of Brewster occurs with the others, and is not a subspecies.*

Of Cypselidae, or swifts, we have two species. The Black Swift (*Nephoecetes niger borealis*) is black without any light markings. The White-throated Swift (*Aeronautes melanoleucus* of Baird) has the under parts white.

The humming-birds (Trochilidae) are undoubtedly of South American origin, but they invaded the temperate parts of North America sufficiently long ago to have given rise to some very distinct forms. The common species in Colorado is the Broad-tailed Humming-bird (*Selasphorus platycercus*); it goes upward in the mountains to 11,000 feet. Related to this, but with the back mainly rufous in the male, the flanks and under tail-coverts washed with rufous in the female, is the Rufous Humming-bird (*S. rufus*). It is found principally in the southwest part of the

*For the anatomy, see Margaret E. Marshall, Proc. Amer. Philosophical Society, XLIV. (1905.)

State. The Black-chinned Humming-bird (*Archilochus*alexandri*) has been occasionally reported, and the Calliope Humming-bird (*Stellula calliope* of Gould) has been taken twice.

PASSERES (PASSERIFORMES)

Suborder CLAMATORES

This suborder, called "songless perching birds", is especially distinguished by the structure of the syrinx, or voice organ. It includes about thirteen families, of which only one, the Tyrannidae or Tyrant Flycatchers, exists in Colorado. This family is confined to the Western Hemisphere, and is not at all closely related to the Old World Muscicapidae, the true flycatchers. From all our other Passeres except the larks the Tyrannidae are known by the tarsus of the leg being rounded behind, instead of sharp. They have ten primaries, the larks having only nine. The Kingbirds were named *Tyrannus* by Lacépède, which seems to show what he thought of kings.** The "crown" is an orange patch on the top of the head, wanting in the other genera. As this crown is lacking in young birds, it is better to examine the outer primaries, which are attenuated or narrowed to a point at the end. The Kingbird (*Tyrannus tyrannus*) is black, gray and white, without any yellow; the other species show canary-yellow on the under side. The Arkansas Kingbird (*Tyrannus verticalis*) was discovered by Say near the present town of La Junta; the common name must be considered to refer to the river rather than to the State. Cassin's Kingbird (*T. vociferans*) has the chin abruptly white; it is best known by the tips of the longer primaries, which are abruptly narrowed at the end, instead of being gradually and evenly narrowed as in *T. verticalis*.*** All these kingbirds are common during the summer. The remaining flycatchers, also distinguished by the lack of white on edge or tip of tail, are referred to five different genera. The slightly crested crown, and rust-red and brown marking on the tail, are the lead-

*Sclater calls this *Architrochilus;* probably through inadvertence, but as he cites no authority, it has the status of a new (synoymous) generic name.

**As a matter of fact, the word originally meant only an absolute monarch, and not a tyrant in the modern sense. The generic name was really suggested because Linnaeus had named the type species *Lanius tyrannus*.

***Mr. Warren notes that the white edging of outer tail feather is a good diagnostic mark of *T. verticalis;* it is practically absent in *T. vociferans*.

ing characters of the Ash-throated Flycatcher (*Myiarchus cinerascens*), but it is quite a rare bird. The other flycatchers have no very striking peculiarities, but the feet are small in *Nuttallornis* and *Myiochanes*, birds formerly referred to *Contopus*. *Sayornis* and *Empidonax* have larger feet; in the former genus the wing is more, in the latter less, than three and one-fourth inches. The tail in *Nuttallornis* is unusually short. The common species are the Olive-sided Flycatcher (*Nuttallornis borealis*), the Western Wood-Pewee (*Myiochanes richardsoni*), Say's Phoebe (*Sayornis sayus*), the Western Flycatcher (*Empidomax difficilis*), Brewster's Flycatcher (*E. traillii brewsteri*) and Wright's Flycatcher (*E. wrighti*). The Least Flycatcher (*E. minimus*) and Hammond's Flycatcher (*E. hammondi*) occur regularly, but are uncommon. The type locality of Say's Phoebe is on the Arkansas River, twenty miles east of the mountains.

Suborder OSCINES

Called the "song birds", though they do not all sing. We may first separate the larks (*Alaudidae*), with rounded tarsus. The Desert Horned Lark (*Eremophila alpestris leucolæma* of Coues)* is a common bird, known by the two little points or "horns" (really feathers) on the back of the head, and the black band across the upper part of the chest. Although our horned larks are in general of one sort, two others races (*E. a. enthymia* and *E. a. praticola*) occasionally occur.

The remaining complex of families forms an evolutionary series showing a decrease in the first primary feather of the wing, but this orthogenetic process has evidently proceeded along parallel lines, as grades of it may be found within the limits of undoubtedly natural families. In a general way, the birds in which the first primary is reduced to a mere rudiment, leaving only nine to be counted, are those which tend to have thick and short bills, culminating in such forms as the grosbeak. Perhaps we should regard the finches in one direction, and the swallows in another, as the apex of avian development. This puts the dominant and aggressive English Sparrow in much the same position among birds as man occupies among the mammals, each un-

**Eremophila* is prior to *Otocoris*, and is not invalidated by the earlier *Eremophilus* of Humboldt.

questionably finding the other a good deal of a pest. But the sparrow has in some respects the best of it, for he profits by man's building operations, whereas man only loses by the sparrow's. For the technical characters of all these Passeres, the reader must be referred to special works, and it will suffice here to enumerate the families, and indicate the species likely to be found.

Near the base of our series, with the outer or tenth primary quite well developed, the sexes alike, and the bill not hooked, must come the Corvidae, or crows, jays and magpies. Everyone knows the Magpie (*Pica pica hudsonica*), a splendid-looking bird with a long tail. On one occasion (at Florissant, by S. A. Rohwer) a Yellow-billed Magpie was reported to have been seen, but it was perhaps a bird which had been eating eggs, and surely not the Californian yellow-billed species. At the same time, it is likely that the yellow-billed *P. nuttalli* originated as a mutation from the ordinary black-billed kind, and if so, such a mutation might occur again. The word piebald comes from the particolored appearance of the magpie. The University of Colorado has a magpie obtained by Jonas Bros., at Littleton, in which the black is replaced by coffee brown, and the head, wings and tail are whitish. Another partial albino magpie was obtained at Magnolia. The Western Crow (*Corvus brachyrhynchos hesperis*), locally common, is known from the ravens by the smaller size (wing hardly 12 inches) and the feathers of the neck not pale at the base. If the neck feathers are pure white at the base, the bird is the White-necked Raven (*Corvus cryptoleucus* of Couch). It was formerly abundant, but has now almost disappeared. It is essentially a southern bird, described originally from Mexico. When the neck feathers are dull gray at the base, and the wing is over 15 inches, the Western Raven (*Corvus corax sinuatus*) is indicated. It is a subspecies of the Raven of Europe. The dark blue Long-crested Jay (*Cyanocitta stelleri diademata*), first made known from Zacatecas, Mexico, abounds among the yellow pines, apparently talking scandal at a great rate. It is perhaps the most characteristic of our Colorado birds. The Blue Jay of the Eastern States (*C. cristata*) seems to be spreading westward over the plains, and has been recorded a number of times from Colorado. Mr. Warren states that it is common at Wray. Two somewhat similar birds with mainly gray (not blue) plumage are the White-

headed Jay or Camp Robber (*Perisoreus canadensis capitalis*) and Clarke's Nutcracker or Clarke's Crow (*Nucifraga columbiana*). Both are seen about camps, feeding on whatever they can obtain, but *Perisoreus* is the bolder bird, and will steal while you are looking at it. Clarke's Crow has a very neat appearance, the wings are black with a white patch, while the tail is black in the middle, white at the sides. The Camp Robber is more fluffy and untidy looking, white on the crown (whence the name *capitalis*), and lacks the conspicuous black areas. Two jays with essentially blue plumage are without any crest. The one with longer tail, the body mainly blue above and gray beneath, is the Woodhouse Jay (*Aphelocoma californica woodhousei* of Baird), found among the brushwood in rocky places. It was first obtained at Fort Thorn, New Mexico. The Pinon Jay (*Cyanocephalus cyanocephalus* of Wied) is said by Sclater to combine the form of a crow with the color of a jay, and a characteristic bill (slender and somewhat compressed) all its own. It feeds on the seeds of the pinon pine, but also (Mr. Warren notes) on corn and any other grain it can steal.

ICTERIDAE

This family is peculiar to the Western Hemisphere, and is richly represented in Colorado. Some of its members are called blackbirds, which may be correct in a descriptive sense, but they have nothing to do with the English blackbird, which is a black thrush.

The Meadowlark (*Sturnella neglecta* of Audubon) is also unfortunately named, for the name *Sturnella* means a little starling, which it is not; nor is it in any respect a true lark. The yellow breast with a broad crescentic black band make it easily recognizable. Audubon called our Western Meadowlark "neglecta," because it had been overlooked as a species, on account of its extremely close resemblance to the meadow lark of the Eastern States. It is only necessary to hear it sing, in order to realize that it is a different bird. Its notes are many and varied, but a phrase often recurring sounds like John Greenleaf Whittier. Another quite unmistakable bird is the Yellow-headed Blackbird (*Xanthocephalus xanthocephalus* of Bonaparte), first recorded (1826) from

near the present city of Omaha. It is a large bird, almost entirely black except the bright yellow head and breast. Vernon Bailey says: "Noisy at all times, they are doubly so on the breeding grounds, where they try to sing, and their hoarse voices come up from the tule borders like the croaking of frogs and creaking of unoiled gates." Brewer's Blackbird (*Euphagus cyanocephalus*) is one of our commonest birds, often seen about cultivated fields, where it goes in flocks. The male is black with greenish and violet tints, but the female and young are brown. The purplish-black Cowbird (*Molothrus ater*) is smaller (length seven and one-half inches or less), and has a brown head; the young are much browner. The bill is short and conical, not long as in *Euphagus*. The Bronzed Grackle (*Quiscalus quiscula aeneus*) is occasionally seen on the plains and in the foothills during the summer.* The tail is rounded or graduated, instead of being parallel-sided and squared off at the end as in Brewer's Blackbird. The Bobolink (*Dolichonyx oryzivorus*), with stiff sharply pointed tail feathers, is a much beloved songbird of the Eastern States, but uncommon in Colorado. Mrs. Florence Merriam Bailey says it is spreading westward. The Red-winged Blackbird (*Agelaius phoeniceus*) is very abundant. The male is black, with a scarlet patch, edged below with pale tawny, on the wing-coverts; the female is brown of different shades, conspicuously streaked, with only a little red on the wing-coverts. Although these birds are migratory, they run into a number of races, three of which have been found in Colorado. These are *A. p. neutralis* (see Univ. of Colo. Studies, vol. VII, p. 139), *A. p. fortis*, and *A. p. arctolegus*. Their characters will hardly be appreciated except by a specialist.** Bullock's Oriole (*Icterus bullocki* of Swainson) was first found in Mexico, but it is abundant in Colorado. It is very like the Baltimore Oriole, which takes its place east of the hundredth meridian. The male, orange and black, with white markings on the wing, is a beautiful object.

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*Mr. Warren writes that during the last two or three years large flocks have appeared in Colorado Springs in September.

**_A. p. arctolegus_ is not recognized in the A. O. U. check list, but Oberholser states that it is clearly different from _A. p. fortis_ by the darker coloration of the female; shorter wing and tail, larger bill, and somewhat paler buff of the wing coverts of the male. It is larger than typical _A. phoeniceus_.

FRINGILLIDAE

The very large family of finches is common to both Hemispheres, members of this group being among the best known birds of Europe. They are dominant, advanced passerines, and we have in Colorado no less than 34 genera. Many of the species are hard to discriminate even with the bird in hand, but some are recognizable at sight. Sclater gives two keys to the genera to facilitate recognition.

The Warren Evening-Grosbeak (*Hesperiphona vespertina warreni* of Grinnell) is a bird which appears in flocks at certain times, entering town and attracting a great deal of attention. It is named after Mr. E. R. Warren of Colorado Springs, who has done so much work on Colorado birds and mammals. It is known by its very large bill; the male with bicolored wings, black and white, and the tail black. The Pine-Grosbeak (*Pinicola enucleator montana*), with rosy tints in the male, greenish in the female, is rather common high in the mountains, in the Hudsonian Zone. The House-Finch (*Carpodacus mexicanus frontalis*), the type of which was obtained by Say near the present city of Pueblo, is common in towns, and has not been exterminated by the English Sparrow. The males, in good plumage, are splendidly red, often causing fresh surprise and pleasure. Cassin's Purple Finch (*C. cassini* of Baird) is not so common. It is a distinctly larger bird, and has the tail emarginate or notched, instead of squared off. The American Crossbill (*Loxia curvirostra minor* of Brehm), easily known by the crossed tips of the bill, is red in the male, olive yellow in the female. In the young the bill is ordinary; Sclater says the fully crossed mandibles are attained at about six months. These birds go in flocks, and occasionally come into towns, as at Boulder. The Rosy Finches* (*Leucosticte*) are birds of the far north and high mountains. Sometimes, after heavy storms, they are driven to lower altitudes. On such an occasion, April 20, 1874, Mr. Aiken found great quantities of Rosy Finches in a vacant lot in Canon City. He actually had not only all the three forms then known from the region (one of them, *L. australis*, described only the year before), but also examples of an entirely

*This vernacular name, used in the A. O. U. list, is better than Rose Finch, adopted by Sclater, or Leucosticte, used in the vernacular sense by Mrs. Bailey.

new species, which Ridgway named *L. atrata*. No additions have been made since that time. The Redpoll (*Acanthis linaria*), which visits in Colorado in winter, was originally described by Linnaeus from Sweden, and belongs to the circumpolar fauna. The pink or red color of the male, which is very bright in the breeding season, is less evident in winter, but still the front of the crown is crimson. The species of *Astragalinus* are called goldfinch, though they are not of the same genus as the English bird of that name. They are quite small birds, the males marked with yellow, black and white; something like a canary with black crown and mainly black wings and tail (*A. tristis*) or with the back olive green (*A. psaltria*). In the Arkansas Goldfinch (*A. psaltria*) the crown is black in the male, green like the back in the female. The type of this species, named from the Arkansas River, was collected near what is now Pueblo. The Pine Siskin (*Spinus pinus* of Wilson) is a small finch of the same build as *Astragalinus*, but streaked with gray and brown, with yellow on wings and tail. It goes in flocks, which migrate from place to place. The English Sparrow (*Passer domesticus*), an introduced bird in our country, needs no description. Kleinschmidt, a German ornithologist, undertook to separate the race found in the British Islands as *P. domesticus hostilis*. If this were accepted, it would also be the name of our American bird, which came from England.* The first recorded English Sparrow in Colorado was that seen by Lowe in Pueblo, Feb. 20, 1895. The Snow Bunting (*Plectrophenax nivalis*) is a northern, circumpolar bird; it was one of the discoveries of Linnaeus during his famous visit to Lapland. It is a rare winter visitor in Colorado. The Longspur (*Calcarius lapponicus*) is another Linnean discovery in Lapland; but our representative of it is subspecies *alascensis*, which breeds in Alaska, and winters in the south.** It is not common in our State. The claw of the hind toe is about as long as the toe itself. There is another species (*C. ornatus* of J. K. Townsend) which remains with us in winter and summer; it is called the Chestnut-collared Longspur, the male in summer having the hind-neck chestnut-rufous. The outer tail feathers are pure white at the base, which is not true of the

*See Oberholser, Auk, 1917, p. 329.

**Bergtold, Auk, 1922, p. 419, records the occurrence of a few specimens of true *C. lapponicus* in Colorado.

first mentioned species. McCown's Longspur (*Rhynchophanes mccowni*) is often found with *C. ornatus;* it is separated by the more swollen bill, and the white on the tail transverse instead of oblique. Sclater gives a special key to the species of the next five genera, known collectively as Grass Sparrows. If the wing is over three inches, the lateral tail-feathers white, and there is median stripe on the crown, it is the very common Western Vesper-Sparrow (*Pooecetes gramineus confinis* of Baird). If the wing is under three inches, and the lateral tail-feathers are not conspicuously white, the bird may have the edge of the wing yellow, and be the rather uncommon Western Grasshopper Sparrow (*Ammodramus savannarum bimaculatus*), or it may have the edge of the wing white, and be one of the three following. Then, if the median crown stripe is buffy in front, white behind, it is Leconte's Sparrow (*Passerherbulus caudacutus* of Latham), which has been taken at Breckenridge. But if the crown stripe is not thus bicolored, should the superciliary stripes be bright yellow, it is the common Western Savannah Sparrow (*Passerculus sandwichensis alaudinus*), or should they be buffy like the ear-coverts it is the rare Baird's Sparrow (*Centronyx bairdi* of Audubon). The Western Lark Sparrow (*Chondestes grammicus strigatus*) is a common summer bird on the prairies; Sclater notes, "It has a clear, rich and varied song, probably equal to that of any of the rest of the family." It is known by the bright chestnut color on the head, with a curved contrasting pale band passing backward from behind the eyes, and a median light stripe on the crown. The Swamp Sparrow (*Melospiza georgiana*) has rather similar markings, but occurs with us only as a rare straggler. The White-crowned Sparrow (*Zonotricha leucophrys*) is one of our commonest birds, the pattern of the head similar in principle to that of *Chondestes*, but the colors black and white. It breeds in the mountains, from about 8,000 feet to timberline. *Z. gambeli* of Nuttall occurs as a migrant.* The genus *Spizella* includes a number of birds of rather inconspicuous appearance, separated from *Zonotrichia* and *Melospiza* by the end of the tail being notched in the middle. The wing is not longer than the tail, as in *Chondestes*. The Western Tree Sparrow (*S. arborea ochracea*) is the largest species (wing over three

*Usually called *Zonotrichia leucophrys gambeli*, but Swarth has recently (1926) given good reasons for considering it a distinct species.

inches), and has a dark spot on the breast. It is an extremely common winter bird, which breeds in Alaska. The others, in which the breast lacks the spot, are the Western Chipping Sparrow (*S. passerina arizonae* of Coues), a common summer visitor; the Clay-colored Sparrow (*S. pallida*), found on the eastern plains; and Brewer's Sparrow (*S. breweri* of Cassin), a summer bird, especially of the sage-brush country. They are distinguished by the markings of the head.

The Snow Birds (*Junco*) are general favorites, and very characteristic of our mountains. They have given rise to much discussion, and some of the peculiar specimens have been regarded as hybrids. Thus the *J. annectens* of Baird, having the chestnut back-patch of *J. caniceps* and the pink flanks of *J. mearnsi*, is treated by Sclater and others as a hybrid between these two. If a *Junco* has the head and back plain gray, it either has a double white wing-bar, and is *J. aikeni* of Ridgway, or it lacks the wing-bars, and is *J. hyemalis*. The former is much the more common with us, the latter is well known in the Eastern States. If the back is more or less distinctly brown or red, and the flanks are strongly pink, it is *J. mearnsi* of Ridgway, abundant in winter along the eastern base of the mountains. *J. oreganus shufeldti* of Coale, also a very common winter bird, is distinguished from the last by the flanks being only slightly pink, the head, neck and chest are black in the male, grayish in the female. In *J. caniceps* the middle of the back is cinnamon-red, strongly contrasting with the slaty head, and the flanks are gray. Sclater noticed that it was not commonly seen near Colorado Springs in winter with the other species, but became abundant in March and April, moving up into the mountains to breed. *J. dorsalis* of Henry, which has been seen in the southwest corner of the State, would be taken for *caniceps*, but the upper mandible is blackish instead of pinkish. An extremely interesting species of this genus (*J. vulcani*) is found on the tops of high mountains in Costa Rica and Panama. It has a streaked back, and is probably nearest to the ancestral form of the genus. No species of *Junco* are found in the Old World. Two birds of the sage-brush plains are the Desert Sparrow (*Amphispiza bilineata deserticola*) and the Sage Sparrow (*A. nevadensis*). The former has a black throat patch, and two white stripes on the grayish-brown head; the latter has the throat white, with blackish

stripes on the side, and a black spot on the chest. The Mountain Song Sparrow (*Melospiza fallax* of Baird) remains with us throughout the year; it is a grayish-brown bird with a white breast, the crown rich umber with a central stripe of ashy gray. The related Lincoln's Sparrow (*M. lincolni* of Audubon) has the upper parts dark brown and olive streaked with black; crown with light central stripe; and there is a broad buffy band, streaked with black, across the chest. It is a common summer bird, breeding high in the mountains. The Towhees (*Pipilo*) are peculiar to North and Central America, with a general distribution similar to that of *Junco*, but not going so far south. The Mountain Towhee (*P. maculatus montanus*) is about eight inches long, with short wings and long tail; above, and on the neck, it is black, but the wings and tail are strongly marked with white. It is a common bird in summer, arriving late in March or early in April. Mr. Warren finds it about Colorado Springs in winter*. The Canon Towhee (*P. fuscus mesoleucus*), found in rocky places, has the crown light rufous, the throat and chest without black, the tail-feathers without white. It is a bird of the Sonoran Zones, but has been seen as high as 10,000 feet. The Green-tailed Towhee (*Oberholseria chlorura* of Audubon) is of particular interest as representing a genus peculiar to Western North America. Seen from above, it appears as an olive green bird with a chestnut red crown, the edge of the wing yellow. It is very abundant in the mountains, especially at the bottom of the canons. Ridgway gave it the very appropiate name *Oreospiza*, but as that had unfortunately been used before, *Oberholseria* was substituted by Richmond. The Rose-breasted Grosbeak (*Hedymeles ludovicianus*), with the under wing-coverts and chest rosy-red, is only accidental in Colorado; but the Black-headed Grosbeak (*H. melanocephalus*) is common in summer.** This last is a cinnamon-brown bird, with mainly black head, the wings black, strongly marked with white, the under wing-coverts and center of belly yellow. The Western Blue Grosbeak (*Guiraca caerulea interfusa****)

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*Mr. Warren writes that the Arctic Towhee (*P. maculatus arcticus*) has also been found at Colorado Springs in winter. The bird identified by Oberholser.

**Our bird has been separated as a subspecies *H. melaniocephalus papago*.

***Dwight and Griscom (Amer. Mus. Novitiates, 1927) restrict the name *Guiraca caerulea lazula* to the bird of Costa Rica and Nicaragua and propose the new name *interfusa* for the race occurring in Arizona, Colorado, Utah, etc.

is in the male a beautiful blue bird with a cinnamon-red patch on the wings; but the female is brown, with only a trace of blue on the rump. It is locally distributed in Colorado. The Lazuli Bunting (*Passerina amoena*), discovered by Say near what is now Canon City, is one of our common but most beautiful birds. Above and on the throat it is bright blue, beneath white, shading into tawny on the chest. There is a conspicuous white band on the wing. This applies to the male; the female is grayish-brown above with little blue. The Dickcissel (*Spiza americana*) is uncommon; it has the breast, stripe on side of head, and patch on each side of throat yellow; a large black patch on middle of throat. The Lark Bunting (*Calamospiza melanocorys* of Stejneger), the type of which came from the plains of the Platte River, is extremely common in summer, often seen sitting on the fences. The sexes are quite different; the male black with a large patch of white on the wings, the female brown above and white below, plentifully streaked with darker. Sclater notes that it is often erroneously called the Bobolink.

TANGARIDAE (TANAGRIDAE)

A family closely related to the finches, but confined to America, North and South. The Louisiana Tanager (*Piranga ludoviciana* of Wilson) is common in summer; its name, like that of the Prairie Dog, recalls the time when Louisiana was a very large country. The male is a bright yellow bird with a red head, a broad black saddle on the back, black tail and mainly black wings. The female appears dark olive green, becoming yellow below, with the middle of the throat either dusky or clear pale yellow; there are two oblique pale bars on the wings.

The Scarlet Tanager (*P. olivacea*, the name originally based on the female), the Summer Tanager (*P. rubra*) and the Western Summer Tanager (*P. rubra cooperi*) occur only as stragglers. Concerning the second, see Oberholser, Proc. Biol. Soc. Washington, 1917, p. 122.

HIRUNDINIDAE

The swallows, found in both Hemispheres, form a very distinct and recognizable family. The primaries of the wing form a

decreasing series, the innermost one not over half as long as the outer; and as the first is practically absent, only nine are to be counted. The long deeply forked tail and cinnamon red under parts distinguish the Barn Swallow (*Hirundo erythrogastra*), which is now regarded by some as a subspecies of the common European bird, *H. rustica*. In winter it migrates even as far as Argentina and Chile, and in fact the original specimen was taken in South America. Our largest member of this family (wing over five inches) is the Purple Martin (*Progne subis*), shining blue black, but gray below in the female. It is not common in Colorado.* In the Cliff Swallow (*Petrochelidon albifrons*) the forehead is white or pale yellowish brown, and the rump is rufous, contrasting with the blue-black. The original specimen was collected by Say near the present Canon City. In the Violet-green Swallow (*Tachycineta thalassina lepida* of Mearns) the rump is purplish, contrasting with the green back, and the under parts are pure white. It is common in the summer, but winters in Central America. In the next three species the rump is colored like the back. The Tree Swallow (*Iridoprocne bicolor*) is steel blue above, the wings and tail black, the under parts pure white. It is not very common, but has been taken in a number of places. The Bank Swallow or Sand Martin (*Riparia riparia*) is circumpolar, going south in winter to the tropics of Asia, Africa and America. It is dusky brown or mouse color above, black or nearly so on wings and tail, not glossy; under parts white, with a grayish-brown band across the chest. It is quite rare in Colorado, according to Sclater. Instead of building a clay nest like Barn Swallow, it makes tunnel-like holes in sand banks. The Rough-winged Swallow (*Stelgidopteryx serripennis* of Audubon) has a short slightly emarginate tail; the color of the bird is grayish brown, darker on wings and tail, the belly white; the breast is not white or banded as in the Bank Swallow. It makes holes in the vertical banks of streams.

BOMBYCILLIDAE

The waxwings, peculiar for the red wax-like appendages to the secondary feathers, are common to Europe and America.

*Linnaeus describes this under two names, *subis* and *purpurea*. Under the latter title we read in Turton's edition: "Inhabits Carolina and Virginia, during summer; is very much esteemed by the inhabitants for its use in alarming poultry of the approach of birds of prey, which it does not only by shrieking but attacking them with the greatest fury."

The Bohemian Waxwing (*Bombycilla garrula*), which occasionally appears in large flocks, was described from Europe. Recent critical studies have however led to the separation of our bird as a subspecies, *B. g. pallidiceps*. The Cedar Waxwing (*B. cedrorum*) is confined to North America. It is smaller than the other bird, with under tail-coverts white instead of chestnut, and the wing feathers without white or yellow tips.

LANIIDAE

The shrikes, which might be called the hawks of the passerine series, have a strongly hooked bill, which distinguishes them at once from their allies. They are common on both sides of the world. Of our two species, one, the Northern Shrike (*Lanius borealis invictus* of Grinnell)* appears in winter; the other, the White-rumped Shrike (*L. ludovicianus excubitorides*) is a summer visitor. The former is larger, and has no black frontal band.

VIREONIDAE

The Vireos, like the humming-birds, are essentially a neotropical group, extending northward into the United States and Canada. The bill is distinctly hooked at the end, thus recalling the shrikes; but this appears to be an independent development, though formerly the two groups were associated. As long ago as 1866, Baird pointed out the distinctness of the Vireonidae. Excluding the two species which appear to occur only as stragglers, our Colorado vireos are as follows. The genus *Vireosylva*, without wing-bars, includes the Red-eyed Vireo (*V. olivacea*) and the Western Warbling Vireo (*V. gilva swainsoni*), the latter the commoner bird. They are very similar, olive green to grayish, with a white stripe on each side of the head; but the back is distinctly olive green in *V. olivacea*, more gray in the other. In the first, also the tenth primary is practically lacking, whereas in *V. g. swainsoni* it is distinct though small. The remaining species have two pale wingbars. The Plumbeous Vireo (*Lanivireo solitarius plumbeus* of Coues) is gray above, with the edges of the wing whitish; Bell's Vireo (*Vireo belli* of Audubon) is olive green above.

*The validity of the subspecies is disputed.

COMPSOTHLYPIDAE (MNIOTILTIDAE)

This is also a purely American family, including our numerous warblers, which are not closely related to the warblers of the Old World. We have eleven genera in Colorado, but *Dendroica* includes twelve species, while all the rest together only include sixteen. Sclater gives an elaborate plumage key, but remarks that it will not always hold good for the females and young. The tail is marked with white in *Dendroica* (with yellow in *D. aestiva*), *Mniotilta*, *Compsothlypis*, *Protonotaria*, and in the Golden-winged Warbler (*Vermivora chrysoptera*), the last known from one specimen taken at Yuma. There are no marks on the tail in the other species of *Vermivora*, or in *Oporornis*, *Geothlypis*, *Icteria*, *Seiurus* and *Wilsonia*. The gape has conspicuous bristles only in *Wilsonia* (under parts mainly clear yellow) and *Setophaga* (under parts white and salmon or yellow). The bill is deep and strongly curved in *Icteria virens longicaudata*, the Long-tailed Chat. This handsome bird (the sexes practically alike) is much larger than the warblers, gray above, with throat and breast most brilliant gamboge yellow. It is a common summer resident. The American Redstart (*Setophaga ruticilla*), with its black and salmon colors in the male, is extraordinary for its resemblance to the European Redstart, which actually belongs to a different family. The female is very different, with crown and sides of head gray, back olive green, and the salmon of the wings, tail and breast of the male replaced by yellow, as is fully described by Sclater. Professor Alfred Newton, contemplating the American and European Redstarts, was led to reflect: "The wonderful likeness, coupled of course with many sharp distinctions, between the birds of these two genera of perfectly distinct origin, is a matter that must compel every evolutionist to admit that we are as yet very far from penetrating the action of Creative Power, and that especially we are wholly ignorant of the causes which in some instances produce analogy."*

No less than fourteen birds of this family are represented in our region only by rare stragglers, so they are omitted here, except the *Vermivora* already mentioned. Full particulars will be found in Sclater's work. We might perhaps add to these the very rare

*A Dictionary of Birds (a wonderful compendium of Ornithology) p. 777.

Oven-bird (*Seiurus aurocapillus*), which has the crown orange in the middle, with a black stripe on each side; the color above is olive green. The great genus *Dendroica* has a slender sharp bill, and the tail always marked with white or (*D. aestiva*) yellow. Thus any warbler with the tail so marked is almost sure to be a *Dendroica*, the few other species with such markings being rare stragglers. We have only six kinds of *Dendroica* which regularly occur, or are common. The Yellow Warbler (*D. aestiva*) is a beautiful yellow bird, sometimes called wild canary; but the true canary is a seed-eating finch, with thick bill.* The Myrtle Warbler (*D. coronata*) has the crown yellow or with a yellow patch; the throat is white, whereas it is yellow in Audubon's Warbler (*D. auduboni*). Grace's Warbler (*D. graciae*) has the crown grey, streaked with black; there is a double white wing bar; the throat and chest are bright yellow. The Black-throated Gray Warbler (*D. nigrescens*) has the head black, the back slaty, a yellow spot in front of the eye. The Townsend Warbler (*D. townsendi*) has the crown black, with a yellow superciliary line on each side, the sides of the head marked with black. Mrs. Bailey, in her excellent "Handbook", describes the various plumages of all these birds quite fully, and gives a key to the adult females in spring, the prominent specific characters being usually based on the males. If one has only a female, the yellow on inner webs of tail will distinguish *D. aestiva*. In the absence of this character, the yellow rump with yellowish throat signifies *D. auduboni*, but with whitish throat *D. coronata*.

Then if the rump is not yellow, and the tail is not marked with yellow, the absence of conspicuous yellow or green markings indicates *D. nigrescens*. If there are such yellow or green markings, the sides of the neck grayish points to *D. graciae*, or yellow indicates *D. townsendi*. The last has the upper parts dull green, streaked. Virginia's Warbler (*Vermivora virginiae* of Baird) has the back gray, the crown with a patch of chestnut, a white ring around the eye, and the rump, tail coverts and a patch on the breast yellow. The female is not so brightly colored, nor is the male in fall and winter. Sclater quotes an interesting account of this bird from Aiken, who was the first to observe it in Colorado.

*Moreover, the canary in its wild state is green, not yellow at all, just as the wild goldfish is dark, and not golden.

The Orange-crowned Warbler (*V. celata* of Say) differs by being olive green above, and the crown patch is orange. Oberholser has proposed a subspecific name (*V. c. orestera*) which includes the Colorado form. The Tennessee Warbler (*V. peregrina*) has no orange or red crown-patch, and the under parts are grayish white instead of the dull yellow of *V. celata*. The back is olive green, with the head and neck ashy brown, or in young birds green like the back. This bird occurs on the eastern plains in migration, and occasionally reaches the foothills. MacGillivray's Warbler (*Oporornis tolmiei* of J. K. Townsend) is very common in the summer, and breeds up to 11,000 feet in the mountains. The head, throat and breast are gray, back olive green, under parts mainly yellow. There are crescentic white marks above and below the eye. The Western Yellow-throat (*Geothlypis trichas occidentalis*) is peculiarly marked, the male having a broad black band across the forehead, enclosing the eyes, extending over the cheeks, and ending in a point behind. The bird is olive green above, yellow below. The female is tinged with brown and lacks the black marking. This is a bird of the plains and foothills, rarely reaching the high mountains. The Pileolated Warbler (*Wilsonia pusilla pileolata* of Pallas) is common in the summer, breeding at high altitudes. The crown is glossy blue black (or paler in the female), the back yellowish green, the under parts yellow. The forehead, eyebrow and cheeks are variably yellow. Pallas originally described the bird from Alaska, in the days when that was Russian territory.

MOTACILLIDAE

The wagtails (*Motacilla*) are among the most characteristic birds of the Eurasian continent, but are absent from America, except as stragglers on the Pacific coast. The pipits, associated with them on structural grounds, have an entirely different appearance, brownish streaked birds with much shorter tails. There are nine primaries, and the hind toe has a long nearly straight claw. The American Pipit (*Anthus spinoletta rubescens*) breeds in Eastern Siberia, and in the northern and mountainous parts of America, while in winter it extends over the United States and even into Central America. It is very abundant in Colorado during migration and may be found breeding at high altitudes, even

above timber line. Sclater describes the eggs as dark brownish-purple, almost hidden by splashes of purplish-black. The pipits are essentially an Old World group, and our bird is now considered a subspecies of the Water-Pipit of Europe. But at some remote time a member of this group reached America, and we have in the interior plains, migrating to Mexico, a single isolated species (*Anthus spraguei* of Audubon) which is so distinct that it forms the subgenus *Neocorys* of P. L. Sclater. It occurs in Montana and Texas, so might be expected in Colorado.

CINCLIDAE

The Dipper or Water Ouzel (*Cinclus mexicanus unicolor*) is the one passerine which may be said to be aquatic. It is often seen on the rocks by mountain streams, plunging boldly into the water in search of food. It is a gray bird with a short tail, very easily recognized by its habits. The genus *Cinclus* is circumpolar.

MIMIDAE

The word *Mimus* means a mimic, or originally a buffoon. Thus our Western Mocking-bird (*Mimus polyglottos leucopterus*) has a name which means in Greek the white-winged mimic of many tongues. It is said to be fairly common during the summer in the southern part of the State. The family Mimidae is peculiar to America, and includes a number of interesting birds. The Cat-bird (*Dumetella carolinensis*) is really a close relative of *Mimus*, but it has no white on wings or tail. The crown, nape and tail are black. It is often seen during the summer, its peculiar cry resembling the mewing of a cat. It is however capable of singing well and imitating other birds. The generic name *Dumetella* was proposed in 1837 by an author of whom we know only the initials, S. D. W. The Sage Thrasher (*Oreoscoptes montanus*) has a spotted breast and squared off, slightly emarginate, tail, the general effect suggesting a thrush. It lives in the arid sage-brush region, and was first described from Wyoming. The Brown Thrasher (*Toxostoma rufum*) is rufous above, with two narrow white bars on the wing, the tail rounded at end; the under parts are spotted with brown. It is a summer bird of the plains

and foothills, wintering in the Southern States. This is another bird which resembles a thrush. The true thrushes (*Turdidae*), with some other families apparently of Old World origin, have the tarsus "booted", not divided into plates except at the extreme base. The Mimidae, along with numerous other related groups, have the tarsus distinctly scutellate or divided into plates in front. Bendire's Thrasher (*Toxostoma bendirei* of Coues) has been found breeding in Huerfano County, but it is rare. It has the upper parts pale grayish brown, the spotting beneath very indistinct, the bill distinctly curved, with the lower mandible yellowish at base. The Crissal Thrasher (*T. crissale* of Henry), with long curved bill, has been found in Utah and Texas, and might be expected in southwestern Colorado.

TROGLODYTIDAE

The wrens are common to both sides of the world, but related to the Mimidae, and almost certainly of America origin. They are richly represented in Colorado, with seven genera. Only one, the Desert Wren (*Thryomanes bewicki eremophilus*) has the tail slightly longer than the wing. It is a rare bird with us, but the records are well scattered over the State. The outer toe is much longer than the inner in the Canon Wren (*Catherpes mexicanus conspersus*) and the Rock Wren (*Salpinctes obsoletus*), both of which occur frequently, the former resident through the year, the latter coming from the south in April. The Canon Wren may be distinguished by the pure white throat and breast. The type locality of the Rock Wren is near the junction of Plum Creek with the South Platte. If the outside toe is not markedly longer than the inner, the bird is one of the four remaining genera. Two of these (*Nannus* and *Cistothorus*) are extremely rare, but the other two occur frequently. The Western House Wren (*Troglodytes aedon parkmani* of Audubon) is cinnamon brown above, the back, wings and tail with dusky cross-bars. The Western Marsh Wren (*Telmatodytes palustris plesius*) has the middle of the back black streaked with white. It lives in marshy places, as its name indicates. Another race of this species (*T. p. iliacus*) has been recorded (Condor, vol. 14, p. 151).

CERTHIIDAE

The Rocky Mountain Creeper (*Certhia familiaris montana*) is an extremely interesting bird, being a passerine with the habits of a woodpecker. With these habits go a certain resemblance in structure, the tail feathers being rigid and sharp pointed. It is a little brown bird, white below, nearly five inches long. The family is an Old World one, and our bird is a subspecies of the common European species.

SITTIDAE

The nuthatches are also a circumpolar group, presumed to be of Old World origin. The bill is rather long and slender, and the tail is shorter than the wing. The sharp barbed tongue shows analogy with that of the woodpeckers, but of course there is no real relationship. The habits are like those of the creepers and woodpeckers, running up and down the trunks of trees, looking for insects.* Our species are the Pygmy Nuthatch (*Sitta pygmaea*), a small bird with grayish olive crown and bluish gray back; the Red-breasted Nuthatch (*S. canadensis*), the top of the head black, with a conspicuous white stripe extending backward from the eye, and the under parts reddish brown; and the Rocky Mountain Nuthatch (*S. carolinensis nelsoni*), our largest form, the head black above, but general color above grayish blue, under side white, posteriorly chestnut. *S. canadensis*, which is placed in a special subgenus *Micrositta*, is not common. The race *S. carolinensis nelsoni* was originally described by Mearns from the Huachuca Mountains in Arizona.

PARIDAE

The titmice or chickadees are small birds with short bills, the body roundish and the head with a very short neck, so that they have a globose appearance except for the outstanding tail. The family is circumpolar, and in view of its affinities and distribution may be considered to have originated in the Old World. We have only four species in Colorado. The Gray Titmouse (*Baeolophus inornatus griseus*) has plain gray plumage and a crested

*Mr. Warren notes that they are the only birds which go down a tree trunk head foremost.

head, living principally in the region of the pinyon pines. The Plumbeous Bush Tit (*Psaltriparus plumbeus* of Baird) is a small bird, less than four and one-half inches long, with no black on crown or throat. It is mainly found in the southern and western parts of Colorado, and is by no means common. It inhabits the same sort of country as the Gray Titmouse. Our Mountain Chickadees, of the genus *Penthestes*, are the Mountain Chickadee (*P. gambeli*) with a conspicuous white stripe above the eye, and the Long-tailed Chickadee, (*P. atricapillus septentrionalis*) without such a stripe, the crown being solid black down to the level of the eye.

SYLVIIDAE

The Sylviidae, which include the true Warblers of Europe, send some offshoots to America, where they almost seem out of place. In the Indian region, as recently so well described by Stuart Baker, there are 33 genera. The minute Kinglets (*Regulus*) are circumpolar. Our common one is the Ruby-crowned Kinglet, *R.* (or *Corthylio*) *calendula*, the crown in the male with a red spot, but no black, in the female merely clouded like the back. Very much rarer is the Western Golden-crowned Kinglet, *R.* (or *Orchilus*) *olivaceus*, considered by some to be a subspecies of the common European bird, *R. regulus*. It has the crown with orange or yellow bordered by black. The genus *Polioptila* of P. L. Sclater* represents a special subfamily. The Western Gnatcatcher (*P. caerulea obscura* of Ridgway) is a rather slender bird about four and one-half inches long, grayish blue above, with a black V-shaped band across the forehead; the tail is black and white. It is a rare summer bird on the plains.

TURDIDAE

The thrush family is very widely spread over the world, but most likely had its origin in the Eastern Hemisphere.** However that may be, it has given rise to some distinct types in America, the most interesting being *Sialia*, the genus of bluebirds. Our

*Dr. P. L. Sclater, for many years secretary of the Zoological Society of London, was the author of innumerable important works on birds and mammals. W. L. Sclater is his son.

**The Old World Prunellinae, with scutellated tarsus, appear to be more primitive than any of our American birds.

common Mountain Bluebird (*S. currucoides*) is splendid bright blue in the male, without any chestnut, much grayer and duller in the female. The Chestnut-backed Bluebird (*S. mexicana bairdi* of Ridgway) is in the male ultramarine above, with a dark red patch on the back, while the sides below and a band across the chest are chestnut. The female is duller colored, as in other species. Sclater says that this bird appears to be confined to the south of the State and to the eastern foothills and neighbouring plains. The Eastern Bluebird (*S. sialis*) is ultramarine above in the male without the patch on the back, and the female has the throat cinnamon like the chest. The female of *S. m. bairdi* has the throat gray and the chest cinnamon. *S. sialis* is a rare bird of the eastern part of Colorado, back to the foothills. Townsend's Solitaire (*Myadestes townsendi* of Audubon) is a bird with a long (about four inches) tail, the general color above slaty gray with two light buffy bars. The bill is quite short and flattened. It breeds in the mountains from about 7,000 feet to timber line, but may be seen at lower altitudes in winter. The Western Robin (*Planesticus migratorius propinquus* of Ridgway) is one of our commonest birds, well known to everyone. Although it is migratory, a few will often be found wintering with us. Although of the same family, this bird is entirely different in size and appearance from the English Robin, the breast of which is bright scarlet or reddish orange instead of rusty red. The Eastern Robin (*P. migratorius*) has been taken at Crook (see Condor, vol. 14, p. 151). It will be known from our common Colorado bird by the darker coloration, and the distinct white spot at tip of inner web of outer tail feathers. The Varied Thrush (*Ixoreus naevius*) has been reported as a straggler in Colorado. The genus *Hylocichla* of Baird includes our thrushes, not remote from the true thrush of Europe, though placed in a different genus. Our commonest one is the Rocky Mountain Hermit Thrush (*Hylocichla guttata auduboni* of Baird), grayish brown above, cinnamon on upper tail-coverts and tail; below white, with triangular dusky spots. The typical *H. guttata*, a smaller bird (wing under five and one-half inches), occurs on migration in summer and autumn along the eastern foothills. There is a record of *H. g. sequoiensis* of Belding as a rare migrant (Condor, vol. 14, p. 151). The Olive-backed Thrush (*H. ustulata swainsoni*) is common in spring and fall. It

U397

has the upper parts of one color throughout, and a buffy ring around the eye. The Willow Thrush (*H. fuscescens salicicola* of Ridgway) is distinguished from the last by the absence of a buffy or white ring around the eye. The legs are flesh colored in life. It is a rare bird in Colorado.

Reviewing the Colorado Passeres, we find fourteen families which are common to the Eastern Hemisphere, and only six peculiar to America. But those six are the Tyrannidae, Icteridae, Tangaridae, Vireonidae, Compsothlypidae and Mimidae. It will be seen at once how important an element these are in the American avifauna. Whence did they come? Surely not from the other side of the ocean, to have died out in their original home. It is practically certain that they are a part of the ancient series of New World birds, having its evolutionary center mainly in South America. Indeed the invasion of North America by several of these groups may not be so very ancient, geologically speaking, else we might expect them to have crossed to Asia in the days when the northern climate was milder and there was continuous land from one continent to the other. In one case this certainly appears to have happened; we may see in the Troglodytidae an equally American group in its origin, which long ago spread to Eurasia, as did the horses and other animals. In the case of the other circumpolar families, the history is not always clear, but in a good many instances we may safely regard them as immigrants to America from Asia; though often that immigration took place long enough ago to have permitted the evolution of very distinct American genera. But of course it did not take place all at once for any of the complex families. The degrees of resemblance to Old World birds, ranging from complete identity to extreme generic differentiation, must depend partly on the plasticity of the several types, but no doubt much more on their length of residence on this continent. We may pause to wonder why such volatile creatures as birds have not spread everywhere, instead of presenting innumerable local races and genera of variously restricted range.* Our Pacific coasts seem well enough suited to the wagtails, which must have wandered to them many hundreds of times more frequently than they have

*Study of the bats of the world has also brought out the fact that the species are by no means so wide spread as their powers of flight would lead us to expect.

been observed. Yet they do not become established. It has been possible, as noted in several places above, to perceive within a few years that certain birds have increased or decreased, owing to the influence of man. But man is not the only factor in the problem. Nature is enormously complex, and we little understand the meaning of many of the phenomena we daily witness. Thus there still remains a great deal to do with Colorado birds, in ascertaining their precise habits, the nature of their food, their enemies and diseases, and how all these things cooperate to keep them within the bounds they observe.

The osteology or study of the bony structure of birds, and the description of their soft anatomy, still afford numerous opportunities for research. Attention may be called to the many admirable papers on avian osteology by Dr. R. W. Shufeldt. Thus in the Bulletin of the U. S. Geological and Geographical Survey for 1882 (vol. VI), we have illustrated papers by him on the bones of *Speotyto*, *Lanius*, *Eremophila* and the Tetraonidae. In the Journal of Morphology, 1889, he presented an elaborate paper on the osteology of the North American Passeres. Subsequent papers, up to the present date, have been so numerous that it is impossible to indicate them. The student of birds, with these papers before him, sees quite a fresh aspect of his science, one little discussed in the ordinary manuals.

Sclater, in his great History of the Birds of Colorado, does not give authorities for the generic and specific names. I have cited them in a number of instances, and when this subject is considered from an historical standpoint, it is not without interest. Thus I find that of all the specific and subspecific names used for Colorado birds, no less than 88 were proposed by the great Swedish naturalist Linnaeus, the father of modern zoological nomenclature. Although he thus named our birds, it is hardly necessary to say that in the eighteenth century none of the specimens were obtained within our limits. Reference has already been made to the work of Thomas Say. Thomas Nuttall (1786-1859), who travelled to the Pacific Coast and Hawaiian Islands, and is best known as a botanist, named three of our birds. Alexander Wilson, born at Paisley in Scotland, 1766, emigrating to America in 1794, studied birds with untiring devotion, and died in 1813. His work was done in what we now call the eastern (and southern)

states, but he gave names to sixteen of the birds we find in Colorado. John James Audubon, born of French parentage in Louisiana in 1780, was endowed with high artistic as well as scientific talent, his great book on American birds being furnished with folio plates in colors, showing the birds in their natural surroundings, the associated plants drawn with equal care.* A copy of this rare book may be seen in the library of Teachers College at Greeley. Audubon died in 1851, having left such a mark on the ornithology of his time that it has since been designated the Audubonian period. Thirteen of our birds were named by him A contemporary of Audubon was Prince Charles Bonaparte, nephew of the famous Napoleon, but devoted to much more. creditable pursuits. Some of his work has been severely criticised, but he made very important contributions to our knowledge.** His active work on American birds dates from 1824 to about 1838. As he wrote so much, he named a great many birds, and fifteen of his names are valid today for Colorado species. An interesting early explorer of western North America was Prince Maximilian of Wied-Neuweid, generally cited as Wied. He named two of our birds, one being the turkey-buzzard. Following the period of Audubon is the period of Baird. Spencer Fullerton Baird (1823-1887) was practically the founder of the U. S. National Museum, and the author of monographic works on American vertebrates.*** Twenty of our birds bear names proposed by him. Dr. Elliot Coues, whom we have frequently cited, was the author of the great Key to North American Birds, a manual dealing with the subject in a very broad and thorough way, and long the bible of our ornithologists. When I met him at Santa Fé many years ago, he told me of his early experiences in Arizona; how he found the red rattlesnake when fleeing from the Indians, skinned it as he rode, and wrapped the skin around his gun barrel; how he got new birds, as he said with picturesque exaggeration "every morning before breakfast." He was an original and indefatigable worker, full of interesting and sometimes rather startling ideas, who did

*The beautiful Dogwood, *Cornus nuttallii* of Audubon, was introduced to science in this manner.

**See Coues, Bull. U. S. Geol. and Geog. Surv .Terr., Sept. 1880, p. 676. He is treated much more kindly in Coues "Key", vol. I, p. xx.

***See Cockerell, Zoology, pp. 520-529.

very much for Zoology. He named eight of the birds in the Colorado list, and is remembered also in connection with the mammals. Four names in our list are due to Dr. Edgar A. Mearns (1856-1916) a worker of the modern period, who is better known for his writings on the mammals. He also did important work on the zoology of the Philippine Islands. Finally, I find no less than 35 names due to Dr. Robert Ridgway, born in 1850, ornithologist of the U. S. National Museum, and author of the great monographic work in many volumes, Birds of North and Middle America. Surely, since the death of Baird, the following thirty years may be called the period of Ridgway.

Chapter 4

REPTILES

In 1887 Mr. George L. Cannon, the well known teacher of Denver, obtained not far from that city part of a large skull, with long, tapering, nearly straight horn cores. Recognizing that he had something very unusual, he submitted it to Professor O. C. Marsh, of Yale University, who could only imagine that the specimen represented some extinct type of buffalo. He accordingly described it as *Bison alticornis*, or the high-horned bison. Two years later, practically complete skulls of the same animal were discovered in Wyoming, and it was seen that they represented no bison, but a gigantic reptile of vastly greater antiquity. This was accordingly named *Triceratops*, the name referring to three horns, there being a smaller one on the nose. As Gilmore (1922) remarks, we must not be too critical of Marsh for his error, because at the time no one suspected that such extraordinary creatures had ever existed. Collectively, these gigantic animals are termed Dinosaurs, or "terrible reptiles." They were exceedingly powerful, but stupid, with very small brains. Some were carnivorous, others herbivorous. Whether the evolving mammals took to eating their eggs, or they ran short of food, or perished of disease, we do not know, but they died out at the end of Mesozoic time. From this period up to the present day the reptiles have been relatively insignificant as compared with the dominant birds and mammals. Yet we have a considerable number of species in Colorado, many of them well adapted to live in dry situations. These are referred to two great Orders, the Testudinata or tortoises and turtles, and the Squamata, or snakes (Suborder Serpentes) and lizards (Suborder Lacertilia).* Some authors raise the snakes and lizards to the rank of separate orders, which would give us three in all.

The terrestrial Box-tortoise (*Terrapene ornata* of Agassiz), with high rounded carapace, is not rare east of the front range. A closely related form, with three instead of four toes on the hind feet (*T. carolina triunguis* of Agassiz) is recorded by Ellis

*The Crocodilia or Crocodiles, now known from warmer regions, once existed in Colorado. In the Morrison beds, near Morrison, a skull has been found and named *Goniopholis felix* (Marsh); while the same rocks near Canon City have furnished vertebrae and ribs, described as *Goniopholis lucasii* (Cope).

Fossil Reptile

Skull of Horned Dinosaur, *Triceratops prorsus* Marsh. A gigantic reptile which lived in the Rocky Mountain Region in upper Cretaceous times. The skull is six feet long. Specimen in British Museum. Brit. Mus. Photo

and Henderson as found by H. G. Smith at Wray. Related to these land forms is the Painted Turtle (*Chrysemys marginata belli* of Gray), which abounds in lakes near Boulder and Denver. It is elegantly marked with yellow, orange or red. There are 25 marginal plates on the carapace.

The Soft-shell Turtle (*Amyda spinifer* of Le Sueur), found in the region of the South Platte, is covered with a thick leathery skin, and the snout is long and tubular. The Snapping Turtle (*Chelydra serpentina* of Linnaeus) is a large and formidable animal representing a peculiar family, Chelydridae. It is known, among other characters, by the long tail. In Colorado it occurs east of the mountains, from the vicinity of Boulder to Wray. The Yellow-necked Mud Turtle (*Kinosternon flavescens* of Agassiz), which has been taken at Lamar, has a narrow carapace, elevated in the middle, not over six inches long. The tail is very short. The under side is yellow, and the neck bright yellow.

In past ages, turtles and tortoises were apparently much better developed in our region. The land tortoises of the genus *Testudo*, related to the common tortoise of Europe, were numerous and in some cases of great size. Cope describes five species from the Oligocene beds on Horsetail Creek, Northeastern Colorado, while Hay made known two from the Miocene Pawnee Creek beds north of Sterling. Hay described an interesting turtle as *Glyptops depressus*, of somewhat uncertain origin, but supposed to have been collected by Cannon in Colorado. Another member of this genus (*G. plicatulus* of Cope) is from the supposedly Jurassic beds at Canon City. *Probaena sculpta* of Hay is from the *Atlantosaurus* beds near Canon City. Other fossil turtles are from the Arapahoe beds on Bijou Creek.

Our lizards belong to three different families. The Scincidae, or skinks, with smooth, polished scales, are represented by the genus *Plestiodon*, with several species. The commonest one is the Sonoran Skink (*P. obsoletus* of Baird and Girard), found in the vicinity of Wellington, Greeley and Osgood. It has five rather indistinct yellowish stripes, and is a large lizard, growing to a length of a foot. Much smaller, blackish to olive green, is the Blue-spotted Skink (*P. guttulatus* of Hallowell), which Beardsley found in Las Animas County. We are also indebted to Professor Beardsley for the discovery in Colorado of

two other species, Hayden's Skink (*P. leptogrammus* of Baird) at Big Bend, Weld County; and the Many-lined Skink (*P. multivirgatus* of Hallowell) near Greeley.

The Teiidae, or Striped Lizards, with deeply bifid tongue, are represented by the genus *Cnemidophorus*. with three species. The common one is the Six-lined Lizard (*C. sexlineatus* of Linnaeus), with narrow light stripes or lines on a dark ground, and extremely long tail. It is found from Grand Junction to Wray, and south to the vicinity of Trinidad. *C. gularis* of Baird and Girard, with pale dots between the stripes, has been reported by Cary from near Golden and other places. *C. tessellatus* of Say, which is striped in the young, but irregularly blotched or marbled in the adult, was first found in the Canon of the Arkansas, but has recently been obtained at Grand Junction and elsewhere.

Our remaining lizards are referred to the family Iguanidae, distinguished from the above by the thick, non-protractile tongue, and the dorsal scales dull, usually keeled. We have six genera reported, but *Dipsosaurus*, given as from Colorado by Yarrow, is a desert animal of the southwest, and its existence in Colorado has not been confirmed. The body anteriorly has transverse rows of light spots, and the long tail is conspicuously cross-banded. It is peculiar for feeding on leaves and flowers.

The so-called Horned Toads, better Horned Lizards, with broad depressed bodies, cannot be mistaken for anything else. Our common one is *Phrynosoma hernandesi* of Girard, considered by Van Denburgh (1922) a subspecies of *P. douglasii* of the northwest. The color varies, and specimens from red soil are likely to be strongly reddened. Ellis and Henderson (1913) recognize an upland or mountain form, true *hernandesi*, and a plains form, the race *ornatissimum* of Girard. The latter was, however, originally described from the mountainous region of New Mexico, and Van Denburgh, in his recent revision, considers all the Colorado specimens to be *ornatissimum*. Both Girard's names were published in the same work (1858), but *hernandesi* has page priority, and should stand for the species, unless we refer both to the aggregate *P. douglasii*. This common horned lizard has short horns, but the Texas Horned Lizard (*P. cornutum* of Harlan) has them considerably longer. It also has two rows of elevated pointed scales along each side of the body, *P. hernandesi* having

only one such row. The Texas species has been found at Denver and Trinidad, and appears to be wide spread but uncommon. The Little Horned Lizard (*P. modestum* of Girard), without a lateral abdominal fringe of elongate scales, and peculiar for having the ear hidden under the skin, is doubtfully reported from Custer County. As it is rather common in New Mexico, coming at least as far north as San Ildefonso, it may be expected to occur in Southern Colorado.

Four genera with the more elongate form of the ordinary lizards are *Uta*, *Crotaphytus*, *Sceloporus* and *Holbrookia*. In the last the ear opening is covered, and the scales are small and smooth. The Spotted Lizard (*Holbrookia maculata* of Girard) is common east of the mountains, from Boulder to La Junta and Trinidad, and east to Wray. It has two or three dark blue or black patches on each side of the abdomen beneath. The Collared Lizard (*Crotaphytus collaris baileyi* of Stejneger) is a comparatively large animal, with a double collar of two transverse black bands, and many small light spots in the back. The tail is profusely spotted. This handsome species is reported from Rifle Gap, Grand Junction, Delta and Trinidad.

The species of *Sceloporus*, or Swifts, are rather thickset lizards, with comparatively large, keeled scales, the keel often produced to a sharp point. Our common form is the Yellow-banded Swift (*S. thayerii* of Baird and Girard*), found across the country from Wray to Grand Junction, but of course not in the high mountains. The Sage-brush Swift (*S. graciosus* of Baird and Girard) occurs in the western part of the State. It is longitudinally striped dark and light, the margins of the stripes conspicuously wavy. The supraorbital plates are in five rows, while there are only four rows in *S. thayerii*. The members of the genus *Uta*, also called Swifts, are more slender as a rule, with the tail very long. There is a gular fold, absent in *Sceloporus*. We have two species in Western Colorado, the Ornate Swift (*U. ornata* of Baird and Girard) and Stansbury's Swift (*U. stansburiana* of Baird and Girard).

U. ornata, belonging to the subgenus *Urosaurus*, lacks the small blue blotch behind the base of the anterior leg, this being

*Recorded as *S. consobrinus* Baird and Girard, but J. P. Jones (1926) shows that *S. thayerii* is the earlier name for the same animal.

present in the other species, which represents the restricted subgenus *Uta*.

Our snakes are readily divided into the venomous Crotalidae, or rattlesnakes, and the harmless (indeed, beneficial) Colubridae. In the Massasauga (*Sistrurus catenatus edwardsii* of Baird and Girard), the general appearance is that of the Prairie Rattlesnake, but the head above has nine large plates, instead of numerous small scales. It is a southern form, obtained by Beardsley in Baca County. The Prairie Rattlesnake (*Crotalus confluentus* of Say) is our common species. The original specimen, obtained on Long's Expedition, probably came from near the place where Fountain Creek joins the Arkansas. A single specimen of the Western Diamond Rattlesnake (*C. atrox* of Baird and Girard) has been found at Trinidad. It will be known by the distinct black rings on the tail, and the diamond-shaped areas on the back.

Our Colubridae include eleven different genera, separated on rather technical characters, but on the whole readily recognizable. The small Black-headed Snake (*Tantilla nigriceps* of Kennicott) is the most distinct, and is said to be somewhat poisonous, though practically harmless to man. It is yellowish or reddish with a black head; the dorsal scales smooth and polished, in 15 rows. It has been taken at La Junta and Yuma. The Garter Snakes (*Thamnophis*) are known by the keeled scales, in 17 to 21 rows, and entire anal plate. They are the commonest of our snakes, usually found in the vicinity of water. The most abundant one is the Western Garter Snake (*T. ordinoides vagrans* of Baird and Girard), recognised by the lateral stripe being on the second and third rows of scales, the dorsal scales in 21 rows, and the superior labial scales eight. Related to this, but with dorsal scales in 19 rows, and seven superior labials, is the Red Barred Garter Snake (*T. parietalis* of Say), discovered on Long's Expedition. It has been found at Boulder, Denver, Fort Collins, Greeley and Julesburg. The other two species have the lateral stripe on the third and fourth rows of scales. The Plains Garter Snake (*T. radix* of Baird and Girard) has seven superior labials, and is common in the vicinity of Denver and Boulder. The Arizona Garter Snake (*T. megalops* of Kennicott) was taken at Rio Grande by H. W. Henshaw in 1873, but has not been obtained in Colorado since. It has eight superior labials. Two other

genera have the anal plate undivided; *Lampropeltis*, with 19 to 25 rows of smooth scales, and *Pituophis*, with 29 to 35 rows of scales. They are not at all alike; the King Snake (*Lampropeltis triangulum gentilis* of Baird and Girard) is rather small and beautifully banded with red, black and light yellow. It is not uncommon east of the mountains. The Bull Snake (*Pituophis sayi* of Schlegel) is very large (up to eight feet), and part of the dorsal scales are keeled. The back is spotted. It is common about Boulder and Denver. A western form (*P. bellona* of Baird and Girard) was obtained by Beardsley at Fruita. The name *bellona* seems to be of uncertain application, as Van Denburgh indicates that it has been applied by various authors to at least six different kinds of *Pituophis*. In the remaining seven genera the anal plate is divided. The scales are distinctly keeled in *Heterodon*, *Natix* and *Storeria;* smooth or very faintly keeled in the others. The Hog-Nosed Snake (*Heterodon nasicus* of Baird and Girard) is very easily known by the upturned snout. It is common on the plains.

The Water Snake (*Natrix sipedon* of Linnaeus) is semi-aquatic, with dull scales in 23 or 25 rows. The body is crossed by numerous dark bands, more or less broken into spots on the back. Specimens have been taken at Boulder, Denver, Wray, and other places. De Kay's Snake (*Storeria dekayi* of Holbrook) has strongly keeled scales in 17 rows. There is a pale stripe down the back, and on each side of this a row of dark spots. A specimen was obtained by Beardsley in Las Animas County.

The Green Snake (*Liopeltis vernalis* of Harlan), green above and pale below, with 15 rows of smooth scales, has been taken at Boulder and Palmer Lake. The Ground Snake (*Sonora semiannulata* of Baird and Girard), which is identical with the *Contia isozona* of Cope, was secured by Beardsley in Las Animas County. It has 15 rows of smooth dorsal scales, and is very conspicuously transversely banded, the pale ground color often reddish. The two last genera, peculiar for the two nasal plates on each side, are *Diadophis* and *Coluber*. In the Sonoran Ring-Necked Snake (*Diadophis regalis* of Baird and Girard) there may be a yellow collar, or it may be absent. The general color above is dark brown to bluish-black, and the under surface is yellow, turning to bright red posteriorly. It is known from Trinidad. The species of *Coluber* are marked with cross-bands or spots when

young, but in the adults the ground color darkens, usually hiding or obscuring the pattern. The Striped Racer (*C. taeniatus* of Hallowell), which occurs sparingly in Western Colorado, is conspicuously marked, even when adult, with narrow dark longitudinal stripes. It has the scales normally in 15 rows, instead of 17 as in the other species. The Coachwhip Snake (*C. flagellum* of Shaw), found from Boulder to Yuma, and south to Las Animas and Baca Counties, is a slender species, sometimes as much as eight feet long. It has eight upper labial scales, whereas there are only seven in the Black Snake (*C. constrictor* of Linnaeus), which also inhabits the eastern plains and foothills. Specimens with the under side yellow belong to the race *flaviventris* of Say, discovered on Long's Expedition. This is the prevalent western form.

As compared with New Mexico, Colorado is about as rich in Amphibians (Colorado 12, N. M., 14) and Testudinata (Colo., 6, N. M., 5), but very much poorer in lizards (Colo., 17, N. M., 32) and snakes (Colo., 22, N. M., 37). It is principally along our southern border that additions may probably be made, and those who will explore the southeastern and southwestern portions of the State for reptiles may expect to make important additions to our knowledge. May we suggest that some of the summer visitors, who hasten from place to place in automobiles, might find here an exciting form of sport, with the added satisfaction of making a positive contribution to science? The southern, rather than eastern, affinities of our lizard fauna are well shown by Ellis and Henderson, who cite five of our seventeen species as found in Kansas, but 15 as found in New Mexico. The latter figure can now be raised to 16, *Eumeces multivirgatus* having been found at Fort Wingate and at the forks of the Rio Ruidoso.

Chapter 5

AMPHIBIA

The Amphibia, evolving from some fish ancestor, discovered the land. A footprint in the Upper Devonian rocks of Pennsylvania indicates the remoteness of their origin, but their actual beginnings may have been considerably earlier. They were not, of course, the first land animals; already the Arachnida, scorpions and mites, had established themselves on land surfaces, and were probably abundant. There were also primitive myriapods. Hirst has recently (1923) made known a series of remarkable Arachnida from the Old Red Sandstone, showing that numerous and diversified types existed, at a time when, so far as we know, the insects had not come into existence. We may infer that this extensive arachnid fauna furnished the food of the early amphibians, and conditioned their development much as the insects in the Mesozoic apparently conditioned that of our mammalian ancestors.

Although we speak of the amphibians as land animals, they have a double life, as the name indicates. The early aquatic stage departs little from the fish type, and each individual, as it develops the terrestrial form, may be said to climb its own family tree. But this course of development is not always carried out, some kinds being permanently aquatic. The Tiger Salamander (*Ambystoma tigrinum* of Green), very common in Colorado, is when adult spotted and blotched with yellow on a black or nearly black ground. It may be found under rocks in damp places. Its aquatic phase, commonly known as the water-dog, may be found in lakes and reservoirs. It is without the yellow markings, and has large tufted external gills on each side of the throat. This is the famous "axolotl", long ago observed in Mexico, and thought to be an adult animal. It does, in fact, under certain conditions reproduce without ever reaching the typical adult condition, and it is easy to imagine that the latter might in the course of time cease to exist. Thus, it has been argued that presumably the permanently aquatic genera of amphibians are not primitive, but derived forms which once had terrestrial ancestors. They are like some flowering plants which no longer flower, but reproduce entirely by tubers or in some other way. The name axolotl has an Aztec form, and according to Gadow means "play in the water".

It may be, however, that it is pseudoaztec, and really a corruption of the Spanish agua lote, water lizard. The *Ambystoma* is our only example of the Caudata, or tailed amphibians; though the many-ribbed Triton (*Eurycea multiplicata* of Cope) was found by Professor J. Henderson in the Jemez Mountains of New Mexico, and may yet turn up in Southern Colorado. This triton is otherwise known from Missouri and adjacent States, and apparently spread into the Rocky Mountain region at a time when the plains were less arid. It now survives in northern New Mexico, and probably other restricted localities, but it is in general ill fitted for life in the now arid southwest.

Our remaining amphibians are all Salientia, the word referring to their jumping powers. They are, as every one knows, tailed tadpoles when young, tailless frogs and toads when adult. We have in Colorado four families of these animals, the Pelobatidae or Burrowing Toads, the Bufonidae, or typical Toads, the Hylidae, commonly called Tree Frogs, and the Ranidae, or typical Frogs. The first two are terrestrial when adult, the others mostly more or less aquatic, with smooth skin. The Burrowing Toads are represented in Colorado by the Western Spade-foot Toad (*Scaphiopus hammondi* of Baird), a brownish or grayish animal, the tubercles more or less red or yellow. The pupil of the eye is vertical, which is not the case in the true toads. It has been found in the vicinity of Greeley by Professor Beardsley. Of typical toads (*Bufo*) we have six species, mostly found east of the mountains, or in the foothills. The Sonoran Toad (*Bufo debilis* of Girard) is a southern species which comes as far north as the vicinity of Trinidad. It is readily known by the absence of bony crests on the head above, and the unspotted under surface. Related to it, but spotted beneath, is the Mountain Toad (*B. boreas* of Baird and Girard). This occurs in the mountains, quite high up, as at Redrock Lake in Boulder County. A third related form, the Red-spotted Toad (*B. punctatus* of Baird and Girard) was found by Henderson and Coffin in San Miguel County, at about 6,500 feet elevation. Like *B. debilis*, it is without the ventral spotting, but it is known by having the warts conspicuously tipped with red or orange. It is a small toad, two or three inches long. The remaining three species have bony crests on the head. If the median crests are parallel, joining the lateral crests at right angles, we have Wood-

house's Toad (*B. woodhousei* of Girard), which is widely distributed east and west, from Lamar to Grand Junction. If the median crests diverge posteriorly, and there is a short diagonal crest at each posterior inner corner, where the transverse crests begin, we recognize the American Toad (*Bufo americanus* of Le Conte). It apparently belongs only to the region east of the mountains, having been found at Boulder, Denver, Brighton and Julesburg. Possibly it has spread into this region since the advent of man, coming from the east. The remaining species, the handsomely marked Say's Toad (*Bufo cognatus* of Say), has the bony crests diverging, with no projecting small crests at the elbows or corners. It belongs to the eastern plains; Brighton, Wray, Julesburg, Greeley, and has also been found in Costilla County. It was one of the discoveries of Long's Expedition.

Our Hylidae, although called "tree frogs", live mainly or entirely on the ground. It is in the moist tropics that their relatives are so abundant on the trees, and often colored green like the foliage. In the Three-lined Frog (*Pseudacris triseriata* of Wied) the toes have scarcely any webbing, and the skin is smooth. It is a small frog, with very variable markings, and extends from the plains high into the mountains. The Cricket Frog (*Acris gryllus* of Le Conte), usually having oblique dark spots on the back, just enters Colorado from the east, having been found by Dr. M. M. Ellis at Wray. The Arizona Tree-frog (*Hyla arenicolor* of Cope), with distinct terminal discs on the toes, is a southern species which has been taken by Beardsley in Las Animas County.

Our only native typical frog (*Rana pipiens*) is common everywhere, and needs no description. The Bullfrog (*Rana catesbeiana*) has been introduced into ponds in the South Platte Valley, but Ellis and Henderson state (1915) that it does not appear to thrive.

Chapter 6

FOSSIL FISHES

Colorado is fortunate in possessing the principal locality where the earliest traces of vertebrate life have been found. At Harding Quarry, west of Canon City, the Ordovician rocks contain innumerable fragments which were described by Dr. C. D. Wolcott as belonging to fishes or fish-like vertebrates. These determinations have naturally not escaped criticism, doubts being expressed both as to the nature of the remains and the age of the rocks. With regard to the first objection, I think it is certain that *Dictyorhabdus*, supposed to belong to the Chimaeridae, is really an invertebrate. We have excellent material of it in the Museum of the University of Colorado, showing the surface sculpture. The other forms are not so easily disposed of. *Astraspis* (the word meaning star-shield) is represented by thick plates exhibiting a reticulated or embossed surface (according to the impression shown), certainly similar in type to those of the primitive fish-like animals of Devonian strata. This conclusion is fortified by the microscopic examination of thin sections, and Dr. C. R. Eastman in 1917 felt able to define a new family Astraspidae, typified by this genus. It is not a true fish,—Jordan places it in a class Ostracophori, but it is a vertebrate of a fish-like type, related to numerous genera found in Paleozoic rocks of later age. Its interest and importance can therefore hardly be exaggerated, for it suggests that the actual origin of the vertebrate phylum must have been considerably earlier, though it may be that no traces of these beginnings will ever be discovered. This, however, is not the whole story. Wolcott's *Eriptychius* is doubtfully regarded as representing a Crossopterygian fish; but other fossils have been found by Professor P. G. Worcester near Ohio City, Colorado, which show strong affinity with Devonian species. A fragment of a plate closely resembles that of *Coccosteus disjectus* from the Old Red Sandstone; another piece is like that of *Rhizodus;* while striated spines agree with those of the Devonian *Diplacanthus*. The first of these represents the Class Arthrodira, the second is Crossoterygian (thus tending to confirm the reference of *Eriptychius*,) the third is a shark. Thus it seems that the vertebrates were not only in existence, but had become

considerably diversified. This conclusion is so remarkable, and the resemblances to Devonian types are so striking, that we naturally wonder whether these rocks are really Ordovician. When Wolcott's specimens were first brought to light, Professor James Hall said that he would certainly have referred them to the Devonian, but for the accompanying invertebrate fauna. When I published the account (1913) of the Ohio City find, I queried the reference to Ordovician, and thereby exposed myself to criticism by more than one paleontologist. The students of the accompanying invertebrates are all agreed that the rocks can only be Ordovician, and this opinion must be accepted in the light of the available evidence.

Passing over a vast interval of time, we may now consider the fishes of the Cretaceous epoch, when the place occupied by our present foothills was the shore of a wide sea. The American Mediterranean, or inland sea, covered the region east of our front range, and also existed west of it, in the territory between the Rockies and Sierra Nevadas. There were of course changes of level, with corresponding changes in the extent of the waters, but the general fact remains that there was a great expanse of relatively shallow warm ocean, connected southward with the Atlantic. In such an area, life was sure to be abundant, and the opportunities for the increase of shallow water and littoral types were far greater than at present. Today if we color on a map the shallow water areas about North America, they appear like rivers running mainly north and south along the coasts; narrow belts in which the development of life is restricted by the land on one side, the deep sea on the other. North and South the changes of temperature interfere with the spread of particular genera and species. The wide inland seas of Cretaceous time seem to have afforded opportunity for the evolution of the various families of modern bony fishes, so that the student may expect to see the earliest representatives of various familiar groups. Not only were the species numerous, but some were of great size. Wonderfully preserved specimens of the gigantic *Hypsodon audax* of Leidy are to be seen at the University of Kansas and in the British Museum; we can but speculate on the fate of the angler who might have hooked such a monster! Unfortunately the fossil skeletal remains of our Cretaceous fishes are abundant only

in the Niobrara formation, but scales are widely distributed through many strata. It was formerly supposed that these scales were of little or no value for scientific study, but recently it has been shown that they present excellent characters.* The matter assumes additional importance from the fact that in many places these scales are the only available fossils which can be used to determine the horizons. Owing to the presence of oil, gas and coal in these Cretaceous formations, the study of fossil fish scales has come to have economic as well as purely scientific significance. Ignorance of the stratigraphic relations has often led to the waste of large sums of money, losses which eventually have to be made good by the public.

Much later still is the fish fauna of the Florissant (Miocene) shales, especially noteworthy for the presence of the interesting freshwater genus *Trichophanes* of Cope. This fish is related to a couple of genera still living in North America; isolated remnants of a group which was formerly much more abundant. Another vanishing type fossil at Florissant is *Amia*, the bowfin; it survives in a common species living today in the Mississippi Valley. The fishes of the Green River shales, much earlier than those of Florissant, but millions of years later than the Cretaceous, are abundant and beautifully preserved in one locality in Wyoming. Many are sold to tourists and others, and they may be seen in museums all over the country. Although we have great exposures of the same formation in Colorado, these fishes have not been found in our State, but the polished ganoid scales of the gar-pike (*Lepidosteus*) are occasionally found. The freshwater fish-family Cichlidae is well represented in the tropics of both hemispheres, with very numerous genera. If, as we must assume, they originated either in America or the Old World, how did they get from one to the other? Some maintain that they crossed in the freshwaters of a land bridge imagined to have connected Africa with South America. How such a bridge could be formed, and why innumerable other types of life did not cross at the same time, is not sufficiently explained. But we have evidence that fishes of this general type existed in the north, and it is much easier to suppose that they took the northward route in the days

*Some American Cretaceous Fish Scales, U. S. Geological Survey, Professional Paper 120-I. (1919).

of milder sub-polar climates. In the Green River rocks of Wyoming there are numerous fishes (*Priscacara* of Cope and *Cockerellites* of Jordan) which differ from Cichlidae only by the possession of small vomerine teeth.

Chapter 7

LIVING FISHES*

The distribution of living fishes in Colorado bears witness to the permanence of the essential features of the topography in recent geological times. The western drainage, of the Colorado and Gila Rivers, contains a fauna fundamentally different from that of the eastern slope. In the eastern part of the State, up to the foothills and sometimes a short distance into the mountains, we find the characteristic species of the western plains region, coming up from Kansas and Nebraska. Several are generally common in the Eastern States. Thus *Notropis*, a very characteristic genus of so-called minnows, has seven reported species from the Platte basin, two of these also in the Arkansas basin, but none in the Rio Grande basin in Colorado, and none whatever on the western slope. They may yet be found in the Rio Grande Valley, as three species occur in that basin in New Mexico. On the western slope they do not exist, and apparently never have existed. An exception to the general rule is found in the Long-nosed Dace (*Rhinichthys cataractae dulcis***), which occurs in Colorado in the Platte, Arkansas and Rio Grande basins, and has also been found west of us in the Great Basin. How this fish came to be so widely distributed is not explained, but certainly it found some way of getting across the divide. Ellis made a careful study of the variations in series from Creede in the Rio Grande basin and Boulder in the Platte basin. There is evidently an incipient differentiation, the Creede specimens having on the average more scales in the lateral line. It is noteworthy that *Rhinichthys* ascends to higher altitudes than most Cyprinidae, having been taken in Twin Lakes. In the case of the native trout, which ascend to considerable altitudes, the fishes of the Colorado River, Rio Grande and Arkansas-Platte drainages are so closely related that they can all be considered races of a single species. Nevertheless, they are appreciably different, and have distinctive subspecific names, provided by Cope. Unfortunately they have now been mixed up as the result of human introductions.

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*See Max M. Ellis, Fishes of Colorado, Univ. of Colorado Studies, March 1914, for full details.

**Dr. C. L. Hubbs prefers to call this fish simply *R. cataractae*, the race *dulcis* having no sufficient distinctive characters.

Further north, *Salmo lewisi* has been seen in the very act of passing from the Pacific to the Atlantic drainage, as is recorded by Jordan and Evermann.

The study of the food of fishes is equally of scientific interest and practical importance. Many feed on insects, molluscs, or on other fishes; but certain species are herbivorous. The number of insects consumed by a single fish is astonishing. On one occasion, in Devonshire, England, Dr. C. L. Perkins studied and catalogued the insects found within a single individual trout.* The list includes a dragon-fly nymph, two kinds of Diptera, six species of ants, a yellow-jacket wasp, four kinds of Hemiptera, a caddis fly and two kinds of caddis fly larva-cases, two sorts of moths, and no less than 45 different species of beetles! It will readily appear from this how dependent our game fishes are on the supply of insects, and thus indirectly on the stream-side and aquatic vegetation. It is true that many of the insects consumed by this trout are themselves predatory, but ultimately all predatory animals have to depend on plant-feeding ones.

To one who would identify our fishes, most of the species present little difficulty, especially if the known distribution is taken into account. The members of the Salmonidae or salmon and trout family are characterized by the soft fins, and small adipose fin over the base of the tail. The native and introduced species are described and tabulated in detail by Ellis in the work already cited. The Whitefish (*Coregonus williamsoni* of Girard) is found only in the northwestern part of the State. It is silvery on the sides, bluish above, without spots. The salmon and trout proper are divided into three genera, of which only one (*Salmo*) is truly native in Colorado. The Mackinaw Trout (*Cristivomer*), a very large fish, has been introduced into Twin Lakes. The fins are much mottled, and there are no bright red spots. The Eastern Brook Trout (*Salvelinus fontinalis*) is now well established and common. It is spotted with bright red (the spots never ringed with white), and the lower fins have the anterior margins white. Our most interesting native trout is *Salmo clarki macdonaldi*, of Jordan and Evermann, found only in Twin Lakes, and now possibly extinct as the result of introducing alien species. It is known especially by the bright yellow pectoral, ventral and anal

*Journal Torquay Natural History Society, 1921.

fins. When we see a fish in which the sides have red spots surrounded or ocellated by white, and the tail is without black spots, it is the European trout (*S. fario* of Linnaeus) purposely introduced. Our American species do not have these ocellated markings, but only black spots. The native Colorado forms have a bright red mark on each side of the throat along the edge of the lower jaw. In *S. clarki stomias*, of the Arkansas-Platte drainage, the spots are comparatively few and large, mainly in the region of the tail; in *S. c. spilurus* of the Rio Grande valley the spots are numerous, of moderate size, and there is usually a pink or reddish lateral band. *S. c. pleuriticus*, from the western slope, differs from the last by the smaller scales, darker color, and very numerous spots over the entire body. A form of the Rainbow Trout (*S. irideus shasta* of Jordan) is now common in Colorado. It lacks the distinct red marks on the throat, the sides have a broad orange or red band, and the ventral, anal and dorsal fins are tipped with white or yellow. The tail fin has black spots, which are lacking in the also introduced Landlocked Salmon (*S. sebago*).

The Catfishes (Siluridae) are well known by their general appearance, barbels (whence their common name) and total absence of scales. In the Channel Cat (*Ictalurus punctatus* of Rafinesque) the tail is deeply forked; the fish is found in the Platte and Arkansas Rivers. A different Channel Cat, not yet certainly identified, is said to exist in the Rio Grande at Alamosa. The Bullhead (*Ameiurus melas* of Rafinesque) has the tail scarcely or not notched, and is a smaller fish. It is frequent in ponds and lakes in the eastern part of the State. Another species (*A. nebulosus*), more lengthened and growing to 20 inches, has been introduced in ponds and reservoirs. For critical determination it is necessary to count the rays in the anal fin, 22 or 23 in *A. nebulosus*, 18 or 19 in *A. melas*. The suckers (Catostomidae) have soft fins, the dorsal with ten or more rays, and the mouth usually inferior rather than terminal, suggesting the common name. On the eastern side of the mountains we have only three kinds, belonging to two genera. The short and deep body, and long dorsal fin, readily identify the Quillback (*Carpiodes cyprinus* of LeSueur*), which has been taken by Professor

*Generally known as *C. velifer* of Rafinesque, but Professor C. L. Hubbs tells me that our fish is distinct from true *velifer*, and is to be called *C. cyprinus*.

Beardsley in the Cache la Poudre near Greeley. The true suckers consist of two very common species of *Catostomus;* one with larger scales, called *C. commersoni sucklii**, and the other with considerably smaller scales, 90 or over in the lateral line, called *C. griseus.* The common large sucker of the Gila and Colorado Rivers is *C. latipinnis* of Baird and Girard. It is related to *C. griseus* of the eastern slope. The Blue-headed Sucker (*Pantosteus delphinus* of Cope) is also found in the Colorado drainage, but the genus is known by the broad, flattened, horny cutting edges on both jaws. The sides of the body beneath are pink or orange-red. Another member of this genus (*P. plebeius* of Baird and Girard) is found in the Rio Grande at Alamosa. The curious Humpbacked Sucker (*Xyrauchen texanus* of Abbott), having a hump in front of the dorsal fin, is found in the Grand River at Grand Junction, and elsewhere on the western slope. The name "texanus," given in 1860, is very unfortunate, as the fish does not live in Texas.

Closely related to the suckers, but in our native species with nine or fewer rays in the dorsal fin, are the Cyprinidae. This very large and dominant freshwater group, including carps, minnows and their relatives, is to the fishes what the Passeres are to the birds, and the Rodentia to the mammals. Most of our species belong to the Platte basin, but they have not been looked for so diligently elsewhere. We have two Old World species introduced, separated from all the native ones by the serrate spine in front of the dorsal and anal fins. The Carp (*Cyprinus carpio* of Linnaeus) has barbels, but there are none in the Goldfish (*Carassius auratus* of Linnaeus). It is a singular thing that the Goldfish has run wild in the Grand and South Platte rivers, and has reverted to the dark green color of its wild ancestors. The Stone-roller (*Campostoma anomalum* of Rafinesque) is an herbivorous fish, with very long alimentary canal; the mouth is much like that of a sucker. There are strong sexual differences, the males being covered with large tubercles in the spring. The sides are mottled with gray, and the dorsal fin has a black or gray band, at least in the adult males. This is one of the commoner fishes east of the mountains. For the detailed

*Dr. C. L. Hubbs is of the opinion that the western race *sucklii* is not sufficiently distinct to be recognized, and would call our fish *C. commersoni.*

characters of the remaining Cyprinidae, the reader must be referred to Ellis, but some of the more interesting may be briefly mentioned. The Red-bellied Dace (*Chrosomus erythrogaster dakotensis**), known by the two parallel blackish stripes along each side, is a beautiful fish, the males in the breeding season splendidly ornamented with red. Evermann's Dace (*Richardsonius evermanni* of Juday) is known only from three specimens collected by Juday in Boulder Creek near Boulder. Since that time the fishes in the creek have been killed wholesale by outpourings from the mines or mills, and continued search has failed to bring another specimen to light. The same is true of the small *Notropis universitatis* of Evermann and Cockerell. This fish, known by the pale orange dorsal band on a bright straw-yellow ground, was considered to be related to *N. zonatus* of the Ozark region of Missouri and Arkansas.** One specimen was found in Boulder Creek at a time when the fishes were killed by mine waste, and none has been seen since. It seems probable that these two species are extinct in Boulder Creek, but we may hope that they survive elsewhere. Another of our *Notropis* (*N. horatii* from Julesburg) is also known by a single specimen, now in the U. S. National Museum. Ellis searched for it at Julesburg, without success, and the species must be considered somewhat doubtful until more specimens are found. The species Ellis and Henderson got at Julesburg were *N. cornutus* of Mitchill, *N. deliciosus* of Girard, (*N. scylla* of Cope), and *N. piptolepis* of Cope, from all of which *N. horatii* appears to differ by having the head 5.2 in length to base of caudal, and anal rays nine combined with an elongate body. *N. cornutus* is a more compressed fish, with a deeper body than the others, especially when adult.*** Ellis records only two native Cyprinidae from the Rio Grande drainage in Colorado. These are *Rhinichthys*, already mentioned, and the Rio Grande Chub (*Richardsonius pulchellus*). The former has a curiously pointed snout in lateral profile, and the mouth is like that of a sucker. The latter is a more ordinary looking fish, without sucker-like mouth; the back is dark steel blue, and be-

*Dr. Hubbs states that the supposed subspecies *dakotensis* is not separable.

**According to Dr. Hubbs, who has examined the type, this is a peculiarly colored individual of *N. cornutus frontalis*, with which the tooth and fin characters (teeth 2, 4-4, 2, dorsal rays 8, anal 9) agree.

***Dr. C. L. Hubbs refers all the Colorado *N. cornutus* to a subspecies *N. cornutus frontalis* of Agassiz, orginally described from Lake Superior.

neath there is a yellowish or orange color about the bases of the fins.

Three native species come from the Pacific slope, representing as many genera not found elsewhere in Colorado. Only one of these (*Agosia yarrowi* of Jordan and Evermann) is small and more or less minnow-like, the length not exceeding five inches. The fish quite closely resembles *Rhinichthys*, and could be mistaken for it. The scales have radii all around; in *Rhinichthys cataractae dulcis* I found about 12 apical radii and five distinct basal ones. Next in size is *Gila robusta* of Baird and Girard, called Round Tail, varying from nine to 15 inches in length, and having a strongly forked tail, curiously swollen at the base. According to Ellis, the form described from Utah as *G. seminuda* of Cope and Yarrow is a subspecies of *G. robusta*, distinguished by having no scales on the mid-ventral portion of the body as far back as the base of the ventrals, and no scales on the mid-dorsal region as far back as the middle or last ray of the dorsal fin. The original specimen appears to have been immature, but a fish about nine and one-half inches long, obtained by E. R. Warren and J. W. Frey in the Bear River at Lily, Routt County, appeared to me to be this *G. seminuda*. The scales are elongate, with parallel or even concave sides, the laterobasal corners prominent though rounded, the basal lobe very large. A new study of *Gila* should be made by some one able to obtain a large amount of material. The third cyprinid of the western slope is the so-called White Salmon (*Ptychocheilus lucius* of Girard), which reaches a length of five feet and a weight of nearly a hundred pounds. It occurs in the Grand, White and Yampa rivers and their tributaries. The caudal fin is deeply forked, and the back is dusky greenish. The young have a distinct caudal spot, and a dusky lateral stripe. There is no abrupt swelling of the base of the tail-fin.

An interesting fish is the Flat-headed Chub, *Platygobio physignathus* of Cope. It is found in the Arkansas River from Salida to Pueblo, and in Grape Creek, which runs into the Arkansas. As the generic name suggests, it has a somewhat flattened head; a matter of considerable interest because in the Himalayas this sort of modification has reached a much more advanced stage in the genus *Homaloptera*, in which the head and

anterior part of the body are conspicuously depressed. This is an adaptive character, making it easier for the fish to live in swift streams. In *Discognathus*, a genus of fishes found in mountain streams of India, Ceylon and Abyssinia, there is actually a suctorial disc on the chin, whereby the fish can adhere to stones.

Investigations are needed to ascertain how far up the mountain streams our various Cyprinidae go. It was a matter for surprise when Howell Ellis found the Black-headed minnow (*Pimephales promelas* of Rafinesque) abundant in Glacier Lake, Boulder County. It has also been found by F. M. Gaige in Bear Creek Lake, a small lake without outlet or inlet, at 9,000 feet on East Spanish Peak, as reported to me by Dr. Hubbs. This is a herbivorous species, the breeding males conspicuous for the black head. The length of the fish is three inches or somewhat over.

The Killifishes or Poecilidae are represented in Colorado by the genus *Fundulus*, with two species. The common name is apparently derived from an old name for brook or creek, which also survives in the word Catskill. The Zebra Fish (*F. zebrinus* of Jordan and Gilbert), which abounds in the streams of Eastern Colorado, is very easily known by the strong vertical dark bars alternating with light ones, the squared-off tail, and the long dorsal fin opposite the anal. The Little Red-fin (*F. floripinnis* of Cope) has a similar tail, very broad at the base, but the body is not barred. The fish is greenish or grayish-green, light below, with the pectoral, ventral and anal fins yellow, with a broad margin of bright red. This fish has been found in various streams in the Platte basin. The type locality is Cherry Creek.*

The common Eel (*Anguilla rostrata* of LeSueur) is reported from the Rio Grande in Colorado, but when Ellis was preparing his work on Colorado fishes, he could not obtain any specimens.

We now come to the "higher" fishes, in which fin-rays are partly spine-like, and the position of the pelvic or ventral fins is far forward, near to or below the pectorals. The stiff spines of the erectile dorsal fin must serve to prevent birds from swallowing the fishes tail first, and allow a good many to escape. We have three families of these advanced fishes, the Cottidae or

*Dr. Hubbs thinks that *F. floripinnis* is a synonym *F. sciadicus* of Cope, described from the Platte River in Nebraska. *F. zebrinus* he refers to Garman's genus *Plancterus*, as *P. zebra* of Girard. He finds that there are two species involved; tho true *P. zebra* of the Rio Grande basin, and *P. kansae* of Garman, the species inhabiting the rivers of our eastern plains.

Sculpins, the Percidae or Perches and Darters, and the Centrarchidae or Sunfishes and Bass. The Cottidae are easily recognized by the absence of scales, squared caudal fin with rounded corners, obtuse head, and two rounded dorsal fins, the second very long. These characters are found in our Rocky Mountain Bullhead (*Cottus punctulatus* of Gill), a species of our mountain streams. It is a variable fish, and Cope has distinguished two other forms, probably not distinct species. The Bullhead is considered harmful, because it eats trout eggs and young trout.

In the Percidae there are distinctly two dorsal fins, the first spinous, the second soft. The large Wall-eyed Pike (*Stizostedion vitreum*) has been introduced into some of our lakes, as also has the Yellow Perch (*Perca flavescens*). Our native Percidae are the various kinds of darters, comparatively or quite small fishes, with the back little or not elevated. They live only in the streams and rivers of the eastern foothills and plains regions. Jordan now places them in a distinct family Etheostomidae, remarking that "these dwarf or rather concentrated perches are peculiar to the waters of the eastern United States." The Johnny Darter (*Boleosoma nigrum mesaeum* of Cope) is found at Boulder, Longmont and Greeley. Technically, the genus is distinguished by the possession of only one spine to anal fin; but the fish is characterized by the black marks forming a sort of checker board pattern, and spotted dorsal fins. The genus with two anal spines is usually called *Etheostoma*, but it now appears that *Poecilichthys* of Agassiz is its correct generic name. We have one species (*P. cragini* of Gilbert) in the Arkansas basin, and one (*P. exilis* of Girard)* in the South Platte drainage. Another species (*P. lepidus* of Baird and Girard) is found near Roswell in New Mexico. These records of darters are of peculiar interest, as they show the western-most extension of this very characteristic North American group.

The only remaining family, the Centrarchidae,** resembles the perches, but the spinous and soft dorsal fins are always more or less united. The scales also differ from those of the Percidae. A scale of a centrarchid type (*Centrarchites coloradensis*) has been

*Ellis and others call this *P. iowae*, but Dr. Hubbs writes that it should be *P. exilis*.

**The names have been revised by Dr. C. L. Hubbs, who has recently paid special attention to this family.

found low down in the Eocene near Walden, Colorado, so it appears that the family has existed for many millions of years in this region. Nevertheless, we apparently have today only one really native species, the Green Sunfish (*Apomotis cyanellus* of Rafinesque). It inhabits the region east of the mountains, and also the Rio Grande. It is a greenish fish, darker above, tinged with orange below, the opercular region, behind the head, marked with blue; length about seven inches, or less. The related Blue Gill (*Helioperca incisor*), marked with double vertical bars, has been introduced in ponds at Pueblo and in the Rio Grande at Alamosa. The Rock Bass (*Ambloplites rupestris*), the Calico Bass (*Pomoxis sparoides*), the Warmouth Bass (*Chaenobryttus gulosus*), the Large-mouthed Black Bass (*Aplites salmoides*) and the Small-mouthed Black Bass (*Micropterus dolomieu*) have all been introduced in the interests of fishermen. *Aplites* approaches the Percidae in the form of its dorsal fin, the spinous and soft portions being connected by a low isthmus. *A. salmoides* has a lateral stripe or series of blotches along the lateral line; there is no such stripe in *M. dolomieu*. The Calico Bass is profusely mottled with dark green blotches, while the fins are striped and spotted. The anal fin is very large. The Rock Bass is a yellowish green fish with a red eye; the sides have numerous narrow longitudinal dark stripes, interrupted at frequent intervals. The anal fin has six spines. The Warmouth Bass, reaching a length of six to ten inches, has a dark spot on the operculum, and the sides of the head are longitudinally barred, the marking not sharply defined. There are only three anal spines.

Chapter 8

MOLLUSCA

LAND SNAILS

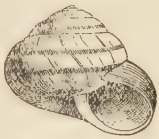
We do not eat snails in this country, nor are they so destructive in gardens as in Europe, so that on the whole they receive scant attention from the public. This is to be regretted, for they are interesting animals, and the study of their distribution will teach us many things about the past condition of this continent. Insects, birds and mammals are relatively mobile; the seeds of plants are often scattered far and wide. But the drama of snail life moves slowly, and where other creatures have departed or changed, land snails remain to testify concerning earlier days. Not all snails are equally significant in this respect. The collector who hunts shells in our western and southwestern states, will find many kinds, large and small. He may naturally suppose that the large species travel faster than the small ones, and hence will be more widely distributed. The exact contrary is true; many of the small forms are scattered all over the country, but the larger ones are restricted to particular mountain ranges, or even parts of ranges. Any conchologist can tell you where to find new species of snails. It is only necessary to take a map of the southwest, note the regions which have been searched, and then investigate such mountain ranges in Arizona and New Mexico as have not yet been explored by any student of snails. The new species thus found will nearly all be large, as large as a coat button or a marble. It seems that the little ones, in a dormant condition, are easily blown from place to place by the high winds. The larger sorts cannot travel that way, and half a mile of sandy desert is just as impassable as the broad ocean. Thus colonies are isolated on mountain peaks, and gradually come to possess distinctive features. This local diversity is very much more pronounced in New Mexico and Arizona than in Colorado, for in our State the valleys are often passable for snails, and there is every reason to believe that during the glacial period the present mountain fauna inhabited much lower levels. Further south desert conditions must have persisted for ages, as shown by the large number of highly specialized desert loving animals and plants.

Land shells are not rarely found fossil, and from the Eocene of Wyoming we have some very extraordinary forms, variously related to those which now inhabit the tropical regions of America. No doubt these also lived in Colorado, but the available fossil land snails of Colorado are of much later date, and resemble those of the southeastern United States. Oligocene time is represented by *Omphalina oreodontis* Cockerell and Henderson, a snail about 24 mm. in diameter, very like the living *O. laevigata* of the southern States. Its mammalian contemporaries belonged to many strange genera now extinct, but the snail, though no longer living in Colorado, has left descendants of the same genus, and in fact closely allied in every way. This *Omphalina* was found at Pawnee Buttes; another species occurs in the later (Miocene) shales of Florissant. Also at Florissant was found the little *Vitrea fagalis*, seven mm. across, apparently belonging to the subgenus *Paravitrea*, now existing in the uplands of the southeastern states. The fossil of course represents an extinct species.

Most characteristic of the genera of Colorado snails is *Oreohelix* of Pilsbry, the name meaning mountain snail. Here are placed the comparatively large coiled snails found in all the upland rocky parts of the State, often in great abundance. The genus is very old, being found as low down as the Paleocene of New Mexico, but in spite of this it has not greatly extended its distribution. Northward it goes to Saskatchewan and Alberta, southward to New Mexico and Arizona. Its present range is evidently contracted from the maximum as there is an outlying species stranded, as it were, on Catalina Island, off the coast of California, and a fossil species in the Post-tertiary deposits of eastern Iowa. One might suppose that a genus of such antiquity, and long residence in the same region, would have reached a condition of great stability, but such is not the case. The species are so variable and often so closely allied that they perplex every student who tries to understand them. How many species should be recognized, becomes largely a matter of opinion, but some of them present good anatomical characters. Two forms are dominant in Colorado, *O. cooperi* of W. G. Binney and *O. depressa*, the latter assumed to be a subspecies of *O. strigosa* of Gould, described from Oregon. The *O. cooperi* is a more globose, elevated snail, more profusely banded, sometimes with the bands confluent.

O. depressa is broader, more depressed or flattened, not so heavily banded as some forms of *cooperi*. They look much alike yet can be distinguished without much difficulty, and Pilsbry has shown on anatomical grounds that they are certainly distinct species. Unfortunately the anatomy of the typical *O. strigosa* is unknown, so that its relation with *depressa* has to be assumed from the general appearance of the shell. Henderson notes that generally speaking *O. depressa* is more prevalent at lower elevations, as along the foothills, though both it and *cooperi* go upward nearly or quite to the timber line. In some localities, where conditions are unfavorable, the shells are very small. The most famous *Oreohelix* locality in Colorado is Glenwood Springs. Here we find remarkable forms, differing on the two sides of the river. On the north side of the river is *O. haydeni* subspecies *betheli* of

Oreohelix depressa Ckll.



Oreohelix cooperi
W. A. Binney

Pilsbry and Cockerell, a large flattened shell with numerous strong spiral ribs or ridges; a very beautiful form. This was first brought to my attention by Mr. E. Bethel, and when I later visited the locality, I found that I had been within a few hundred yards of it in 1887, but had never suspected the existence of the prize that I so narrowly missed. The typical *O. haydeni* came from Utah, and is still known only from the lot originally collected. On the south side of the river at Glenwood Springs, about the bases of the dwarf oaks, we find a different snail, more globose, with higher spire, and less sharply ribbed. This has been called *alta* by Pilsbry, and on the mountain above the station for *alta* is still another form, which Pilsbry named *mixta*. With all this complexity in a small area, it is a question what may be found when the whole country round about has been thoroughly searched. There is here an excellent opportunity for the local naturalist. Very rarely, specimens are found with the spiral reversed, the aperture to the left instead of to the right, when the shell is viewed from the side. No one knows the cause of this, but some genera of snails (as the water-snail *Physa*, and the land-snail *Clausilia*)

are regularly sinistral, as it is called. The reversed spiral begins with the first cleavage of the egg, and after that cannot be altered. In the Hawaiian Islands there are land snails which may be indifferently sinistral or dextral. Thus, of six examples of *Auriculella auricula* before me, four twist to the right, two to the left. Another Colorado *Oreohelix*, described by Pilsbry as recently as 1912, is *O. hendersoni*. It was first found along Little Thompson Creek, about ten miles northwest of Longmont. The shell is smooth, depressed or somewhat elevated, without distinct color bands, though these are more or less visible on the first whorls.

When we go south of the Colorado border, into New Mexico, we find species of a very different genus of snails; the shells brown, bandless, usually shining, the aperture with a heavy white lip. They mostly have a diameter of about 15 mm. When these snails were first discovered, they were placed without question in *Polygyra*, which includes many common species of the eastern states. But the Rev. E. H. Ashmun, an indefatigable collector of snails, obtained living specimens, and dissection showed at once that we had a perfectly distinct genus, not even closely related to *Polygyra*. It was accordingly named *Ashmunella*, and since then very numerous species have been discovered. Although this genus must have inhabited New Mexico and Arizona for countless years, no traces of it have been found in Colorado. It must be said, however, that our southern border has never been properly searched, and some one may yet be rewarded by the discovery of a Colorado *Ashmunella*.

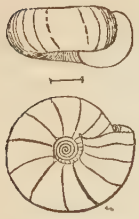
The form of *Oreohelix cooperi* found in the loess of Iowa was somewhat distinctive, and was named *iowensis* by Pilsbry. In the same manner, a small depressed coiled snail common in Colorado has a representative in the Iowa loess; but as it happened, the fossil was the first to receive a valid name. Therefore *Gonyodiscus shimekii* is the name of the Iowa fossil, and *G. shimekii cockerelli* is the subspecies still living in the Rocky Mountains. Both names are due to Pilsbry.

Very elegant little snails, less than three and a half mm. diameter, belong to the genus *Vallonia*. There is a distinct lip to the aperture, and the surface of the shell may be smooth (the introduced *V. pulchella*) or with fine transverse ribs. Over thirty years ago, it was customary to refer these shells to well-known

European species; but Ancey, a French naturalist, protested that some of them represented perfectly distinct kinds. His views were at first received with ridicule, until Dr. V. Sterki of Ohio took the matter up, and in 1893 published a revision of the genus. He out-Anceyed Ancey, and was even able to show that a common European species had been overlooked, and provide it with a name. It was one of those cases where nobody can see a thing until it is pointed out; then every one can see it. There are four native species of *Vallonia* widely distributed in Colorado, and a fifth much less common. Their characters and localities are given in Henderson's work, University of Colorado Studies, XIII, No. 2.

In 1864 Dr. E. S. Morse gave the name *Punctum* (a point) to a genus of very minute snails found all around the world in northern regions. They come near satisfying the definition of a point as that which has neither length nor breadth, the typical species being only a little over a millimeter in diameter. The jaw is peculiar for consisting of a series of distinct subquadrate plates, instead of a solid arched structure as in more ordinary snails. It is possible to extract the jaw and lingual membrane from these minute animals by crushing the shell, and subjecting the soft parts to the action of a solution of caustic potash, which dissolves the tissues, leaving the chitinous parts intact. The excessively minute teeth on the lingual membrane have been estimated to number about 4,400. The common European species of *Punctum* has been appropriately called *P. pygmaeum*, and it is generally supposed that the same snail exists in Colorado and other parts of North America. There are however some differences, so that the American shell has been treated as a subspecies, *P. pygmaeum minutissimum* of Lea. Morse counted only about 1,400 teeth on the lingual membrane, but not enough counts have been made to determine whether there is any constant difference in this respect between European and American specimens. The first Colorado specimen of this little snail was found many years ago in Custer County. About fifteen years ago Mrs. Cockerell obtained others at Tolland, by collecting a quantity of debris from under the aspen trees, and sorting it on a sheet of paper. By such means it is possible to see the shells, but it takes extraordinarily sharp eyes to detect them on the ground in the forest.

A curious little shell about 4 mm. across, discoid with a very narrow aperture and practically flat upper surface, is the *Microphysula ingersolli;* named by Bland in 1876 in recognition of the work of Ernest Ingersoll on Colorado snails. It is quite common in the mountains and is interesting because it represents a group especially characteristic of Mexico and Central America. It adds one more to the numerous cases of southern types extending northward, and meeting those (such as the *Punctum*) of boreal distribution.



Microphysula ingersolli Bland (Enlarged)

The family called Zonitidae consists of coiled shells, usually known by the smooth surface and simple margin of the aperture, this margin being fairly or very ample, not narrowed as in *Microphysula.* The one (*Euconulus*) in which the aperture is rather narrow has a broadly conical spire or upper portion, and is reddish brown. Like the *Punctum*, it is considered a subspecies (*E. fulvus alaskensis*) of a common European form. *Zonitoides arborea* of Say is a very common species, about 5 mm.

Euconulus fulvus alaskensis Pilsbry (Enlarged)

Vitrina alaskana Dall

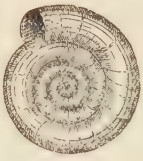
across, with a very distinct umbilicus or opening beneath. The name might be taken to mean that it is found on trees, but it is to be sought for among the vegetation and debris at their bases. *Vitrina* (glass shell) has in Colorado a single representative, called by Dall *V. alaskana.* It is pale greenish, excessively thin and fragile, with an extremely large aperture. When alive, the animal is seen to be very large and exposed, so that there is some resemblance to a slug. One would suppose that such a creature would be very susceptible to cold, but actually it crawls about in cold weather, when most other snails have gone into hiding. There is even a species of *Vitrina* living in Greenland. The transparent shell permits the pulsations of the heart to be seen. In the case of the English *Vitrina* it was noticed that the heart beat 51 times a minute when the snail was on a cool table, but when it was placed on the warm hand of the observer, the beats increased to 98.

The land snails so far discussed have the form called helicoid, that is, with a more or less flattened spiral. Another type of shell has been called pupoid or pupilloid, the shape being that of a small cylinder, or barrel, or spindle. A very common member of this series, 5 or 6 mm. long, with shining surface and rounded contours, is *Cochlicopa lubrica*. The very same species is abundant as far away as England, and I have found it in Siberia. Its numerous relatives belong to the European region and along the Mediterranean; there are many species in the Madeira Islands. Just how this snail has managed to travel so far, and keep its characters unchanged, is a mystery. Curiously enough, it is much less variable in Colorado than in England, whence nine named varieties have been recorded. Other pupilloid snails are very small, and difficult to identify without a microscope or very good lens. The commonest ones belong to the genera *Pupilla* and *Vertigo*, and are boreal types.

Vertigo ovata Say (Much enlarged)

Vertigo concinnula Ckll. (Much enlarged)

Gastrocopta armifera Say (Greatly enlarged)



Helicodiscus parallelus Say (Much enlarged)

The amber snails, *Succinea*, are more or less fusiform, with a pointed spire, and the suboval aperture so large that it is more than half the length of the shell. We have several species in Colorado, and the genus is widely distributed over the world, especially on remote islands.

Succinea haydeni Binney

Succinea avara Say

SLUGS

Slugs are distinguished from snails by the apparent absence of a shell. In some genera it is totally absent; but in the Limacidae, to which our Colorado slugs belong, it is represented by a flat plate concealed beneath the skin. In other countries there are animals in which the shell is clearly visible on the outside, but still so small that we class them with the slugs rather than with the snails. Such is the carnivorous slug of Europe, *Testacella*, which feeds on earthworms. The Pacific coast region of the United States is rich in slugs, some of them very large, but in Colorado we have only one native species. This is a small dark or pale brown form common in the mountains, under stones in damp places. Ingersoll, in the Report of the Hayden Survey for 1874, described two supposed new species, *Limax montanus* from Hot Sulphur Springs, and *Limax castaneus* from the Blue River Valley. The first of these names could not be used in any case, as there is an earlier *Limax montanus* Leydig, 1871. This is however a matter of small moment, for it appears certain that both Ingersoll's slugs are referable to *Agriolimax campestris* Binney, described in 1841, and known to be very widely distributed in North America. This *A. campestris*, in turn, is with difficulty separated from the European and Asiatic *A. laevis*, so that it seems to deserve only subspecific rank. Very dark, nearly black, examples of the Colorado slug have been described as a variety *tristis;* they seem to be very frequent at high altitudes.

The slugs of this group present a curious biological problem. They are found all around the world, and in tropical as well as in temperate countries. They exist in Australia and on the remote islands of the Pacific, as well as in Jamaica and Brazil. Various authors have described them as distinct species, but the differences are slight, and in many cases it is very doubtful whether they are really indigenous in the places where they have been found. The student of geographical distribution recoils from the proposition that a slug found in Labrador and the Commander Islands can belong to the same species as one from Brazil and Madagascar. The matter deserves renewed study, with more abundant materials than any single author has yet possessed; but certainly, whether there is one species or a series of them, the

general type is amazingly conservative in structure, yet plastic in its adaptations to different climates.

Another species of *Agriolimax*, the *A. agrestis* of Europe, has become naturalized in certain gardens in Boulder. It is quite a pest, and seems to have a particular liking for choice orchids.

Agriolimax agrestis Linnaeus

Agriolimax campestris Binney

This species is larger than the native one, when well grown about 35 mm. long, usually pale reddish or grayish, and often with gray or black spotting. The most distinctive feature, however, is the possession of milky slime. Specimens of *A. agrestis* received from the Colorado Agricultural College were collected by J. H. Newton of Paonia, where they were (1924) injuring ripe tomatoes.

Two other foreign slugs, brought in with plants, have been observed in Boulder gardens. One is *Limax maximus*, a very large species with the mantle or covering of the anterior part of the body prettily spotted or marbled. The other, called *Milax gagates*, is of moderate size, with a sharp keel or ridge down the back, especially noticeable when the animal is at rest. Two other kinds of slugs have been found in a greenhouse at Boulder, but have no permanent place in the fauna.

FRESH WATER SNAILS

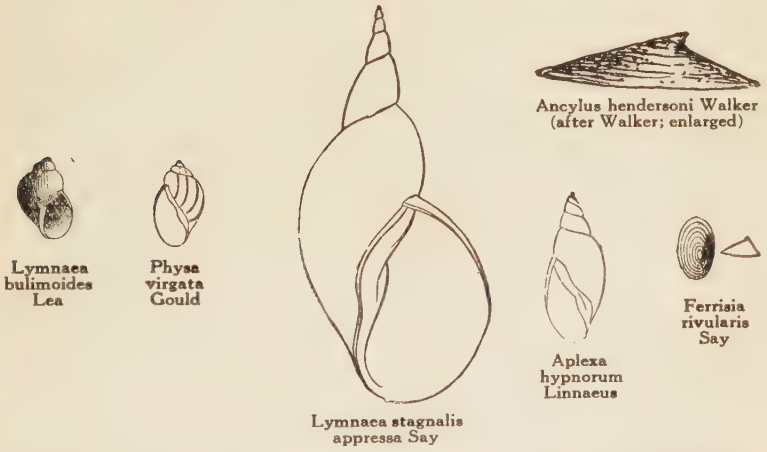
Fresh water snails may be divided into two great groups according to their mode of respiration. Undoubtedly the more primitive method is by gills or processes of the body, absorbing the oxygen which is dissolved in the water. The original molluscs were certainly aquatic, and presumably marine; but many millions of years ago some of them, just as with the vertebrates and arthropods, discovered the land, gradually becoming adapted to terrestrial life. Their subsequent history also shows a curious parallelism. Among the vertebrates, certain terrestrial groups produced members which took to the waters, reversing the original sequence of events. Doing so, they could not return to the old

gill-breathing condition of the fishes; consequently the whale still breathes air, and can be drowned by being deprived of it. Among the arthropods, we have such forms as water beetles and water spiders, which breathe air, but carry it with them in the water, in the form of a bubble attached to the body, or beneath the wing covers. So also with the snails, for the typically terrestrial air-breathing (pulmonate) type has given rise to a large group of aquatic forms which still breathe air, though living in the water. The so-called lung of these animals opens by a single aperture beneath the edge on the mantle, which of course is a very different thing from the internal lungs of terrestrial vertebrates, the latter originating as outgrowths from the alimentary canal. In the fresh water lung-breathing snails, individuals may be seen coming to the surface to get a supply of air, just as a whale has to do. Nevertheless it is sometimes possible for these snails to live without access to the atmosphere, for it has been observed that some of them live at great depths in the Lake of Geneva, and absorb the necessary oxygen for their sedentary lives from the water. It appears that these species (belonging to the genus *Lymnaea*) are able to absorb oxygen not only through the surface of the lung but also through the surface of the body generally, the skin being sufficiently thin. Possibly similar snails will eventually be found in the depths of some of our cold lakes, which have not as yet been sufficiently explored. Another conspicuous difference between these two groups of our freshwater snails is found in the fact that the gill-breathers possess an operculum, which the lung-breathers lack. This operculum is a sort of a lid which, when the snail is within the shell, closes the aperture or so-called mouth. In some of the sea-snails, the operculum is very thick and heavy, but in our kinds it is very much thinner, and of a horny consistency.

The operculate snails of Colorado are rarely seen; in fact it appears probable that there is only one living species, the small coiled subglobose *Valvata sincera* of Say, with a diameter of five or six millimeters. This has been found in the San Luis Valley and in Rio Blanco County. Several other freshwater operculates occur in Utah. It is evident from the fossil operculates found in our Tertiary and Cretaceous rocks that Colorado was once inhabited by a great variety of these snails, some of them

quite large. These were allied in a general way to those now inhabiting the Mississippi Valley, where may still be found genera of molluscs and fishes long ago extinct in Colorado. The elevation of the land drained off the waters, and created conditions unsuitable to the continued existence of many forms of life. Eastward, the land indeed rose out of the sea, but great rivers and bodies of standing water were favorable for the survival of ancient types of freshwater life. Possibly the dinosaurs survived longer than we think in these regions. The great lakes of the north, unlike Lake Baikal in Siberia, have not conserved the relics of past times. They were formed in a very recent geological epoch, and are relatively speaking of modern origin.

Our pulmonate water snails are much more numerous, and some of them quite interesting. They belong to a few genera, easily recognized. *Planorbis* (the name meaning flat circle) is coiled in one plane, though the whorls may be quite broad. *Lymnaea* is suboval or conical, with a pointed apex, and the aperture is to the right when the shell is held with it in view. *Physa* is not

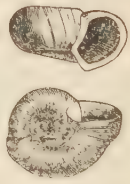


unlike *Lymnaea*, but the aperture is to the left, and the shell is said to be sinistral. Many authors separate from *Physa* the genus *Aplexa*, which has a narrow, highly polished shell. Our only species (*A. hypnorum* of Linnaeus) is also common in Europe. The remaining type is like a little limpet, though not at all related

to the large marine limpets so common on the sea shore. Our recorded Colorado species of freshwater limpet is a member of the American genus *Ferrissia*, but Professor Junius Henderson has lately made the very astonishing discovery of a new species of *Ancylus* (*A. hendersoni* of Walker,) in Lake Eldora. This is remarkable, because the genus *Ancylus* as now understood was supposed to be restricted to the Old World. Evidently we have a survival of the boreal fauna in these cold alpine waters.

An interesting little snail is the *Physa cupreonitens*, found in a warm spring, or rather stream running from it at Wellsville in Fremont County. It was discovered by the present writer in 1887, and described in 1889, taking the name *cupreonitens* because of its shining coppery-red shell. In 1924, about 36 years later, Professor Henderson went to the exact spot, and obtained a bottle full of the snails, so that they can now be distributed to collectors and museums. About 17 species of *Physa* have been reported as living in Colorado, but it is probable that the actual number of valid species is not so great. They should be collected in quantities, and by the study of their anatomy, including the lingual membrane, it will eventually be possible to define the species with exactness. Our larger *Planorbis*, with broad whorls, belong to the subgenus *Helisoma*. The larger one, *P. trivolvis* of Say, has the shell very variable in size, from 15 to 30 mm. in diameter. Although it is difficult to perceive the fact in such a shell, the coil is sinistral; whereas in the other species, *P. antrosus* of Conrad, it is dextral. This *P. antrosus*, which is about 12 to 14 mm. across, was originally named *P. bicarinatus* by Say, because it has the whorls more or less evidently keeled above and below. Unfortunately Say's name was a homonym; that is, it had been earlier used for another kind of *Planorbis*, and therefore could not be employed again. Many years ago Ingersoll found a *Planorbis* living in quantity in St. Mary's Lake, Mineral County, the shells being peculiar for the distortion of the whorls, the coiling being irregular instead of in a single plane. He called this *Helisoma plexata*, but it has been shown by subsequent writers that it is

Planorbis trivolvis Say



Planorbis antrosus Conrad

only an abnormal form of *P. trivolvis*. Henderson suggests that the snails may have been affected by a parasite, but this is subject to confirmation. Similar abnormalities are known in other species of *Planorbis*. I have seen a specimen of the fossil *P. euomphalus* of Sowerby, from Tertiary beds at Headon Hill, Isle of Wight, in which the coiling is so irregular that one might be at a loss to guess the genus of the shell. Yet, strangely enough, irregularities in coiling are not necessarily abnormal in snails. A most extraordinary case is that of the little land snail *Protoboysia*, fossil in the Eocene strata in Clark's Fork Basin, Wyoming. The shell has a broadly conoid form, with many whorls, but the last whorl is abruptly directed upward, obliquely wrapping the spire, curving round it near the apex. This is the regular structure of the genus, all the individuals being the same. Although the *Protoboysia* has only been found in Wyoming, it doubtless also inhabited what is now Colorado.

The species of *Lymnaea* are rather numerous, some of them large and handsome shells. Very big ones with a long tapering spire are *L. stagnalis*, a species very common in Europe as well as America. The American forms are usually referred to the subspecies called *appressa* of Say, and this includes apparently all the Colorado shells. A shell with a very wide aperture and expanded lip, but the spire short and sharp, is the *L. auricularia* of Linnaeus, the name referring to the resemblance to the human ear. This is not a native of Colorado but of Europe; it has been found, accidently introduced in some way, at Colorado Springs and near Fowler. Although *Lymnaea* is a genus of aquatic snails, some of the species can survive for a considerable time out of water. The broad rounded *L. bulimoides* subspecies *cockerelli* of Pilsbry and Ferriss is found in pools near the foothills in Montana, Colorado, New Mexico, etc. These pools dry up, and the snails, as well as certain Crustacea, survive in the mud, ready to resume activity whenever the rains come. Pilsbry had some of these snails packed in cotton for 45 days, but on putting them in the water they cheerfully crawled about, and even when supplied with water were often seen leaving it and crawling to the top of the glass in which they were confined. On one occasion I found a number of small *Lymnaea* snails on the outside of flower pots in a greenhouse at Boulder, Colorado. They were on a moist

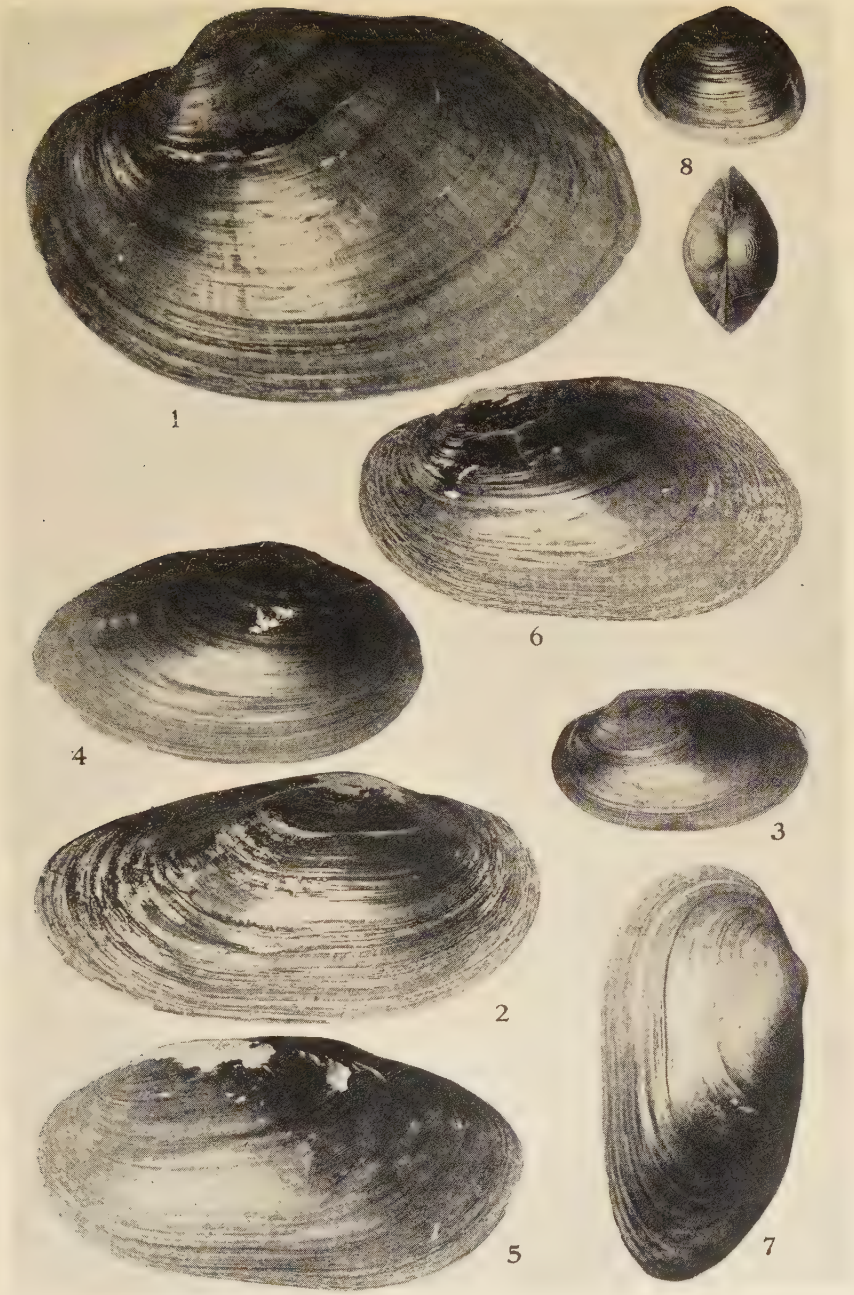
surface, but in the air. They had undoubtedly been introduced with plants, and Mr. F. C. Baker, in his monograph of North American Lymnaeidae, figured and described them as a species unknown to him. Their place of origin, and proper specific designation, still remain unknown. The habit of leaving the water doubtless contributes to the spread of the liver fluke disease, from which it was formerly estimated that a million sheep died annually in the British Islands. A small snail, *Lymnaea truncatula* (very closely related to one common in Colorado) harbors the young liver fluke. The young flukes, leaving the bodies of the snails, attach themselves to the grass at the edge of the pond. This grass, being well grown and succulent, is eaten by the sheep, and the flukes develop to full size in the livers of the unfortunate animals, which consequently perish. The eggs of the flukes are scattered over the pastures, and washed by rains into the ponds or ditches, and so the snails become infested.

The oldest known American Lymnaeas are three species described by White, found in the Atlantosaurus Beds, of the Comanchean period, about eight miles north of Canon City. Two of these, although many millions of years old, are very like species still living. The third is peculiar, and perhaps belongs to another genus. There are fossil species of *Lymnaea*, and also a *Planorbis*, in the Miocene shales of Florissant.

FRESHWATER BIVALVES OR CLAMS

In Cretaceous and early Tertiary times the Rocky Mountain region possessed a varied assemblage of large freshwater mussels, such as may be found in the Mississippi Valley today. So far as we may judge from the shells, they represented a number of genera now living, but the determination of genera in this group from shells alone is a matter of great difficulty. In recent times careful studies of the soft parts of living species have been made, with surprising results, indicating a large number of diverse genera.

Many years ago C. T. Simpson found five kinds of freshwater mussels (Unionidae) in or near Lodgepole Creek, northeastern Colorado, in the Platte drainage. Henderson notes that in the report of the Fremont Expedition (1845) it is stated that in July 1842 Lodgepole Creek was a clear, handsome stream, with a



FRESHWATER MUSSELS

1. *Lampsilis ventricosa* **Barnes.**
2. *Strophitus edentulus pavonius* **Lea.**
3. *Anodontites ferussacianus* **Lea.**
4. *Anodonta grandis* **Lea.**
5. *Lampsilis anodontoides* **Lea.**
6. *Lampsilis siliquoidea* **Barnes.**
7. *Uniomerus tetralasmus camptodon* **Say.**
8. *Sphaerium hendersoni* **Sterki.** **(Enlarged.)**

uniform breadth of 22 feet, and six inches in depth. Simpson states that in his time (the '80s of the last century) it was six to eight feet wide, and sometimes went dry. In 1912 Professor Henderson and Dr. M. M. Ellis visited the spot and found the stream narrow and shallow with only one pool on the Colorado side of the boundary. Nothing could then be found of Simpson's mussels, except a few dead shells of one species (*Anodontoides ferussacianus*). Although our mussel-fauna in the northeastern corner of the State has thus apparently perished, certain species exist elsewhere, and it is probable that irrigation operations have even favored the spread of one or two kinds. At all events, *Strophitus edentulus* race *pavonius* of Lea has been obtained at Windsor and east of Boulder, while *Anodonta grandis* of Say is reported by Henderson 30 miles north of Denver. Other species have been found in Black Wolf Creek, Yuma County, and Carrizo Creek, Las Animas County. Careful search should be made in all counties along the eastern border, and it may be that additional forms will be discovered.

The small freshwater bivalves are placed in the genera *Sphaerium*, *Musculium* and *Pisidium*. The first two include shells of moderate size, but considerably less than an inch in diameter, more or less transversely oval, and considerably swollen. A member of this group (*Sphaerium* or *Musculium florissantense*) is found in quantity fossil at Florissant. Among the modern species, the most interesting is the handsome *Sphaerium hendersoni* of Sterki, discovered by Henderson in Crow Creek, northeast of Greeley, and described in 1906. Henderson revisited the locality in 1912 and 1921, but the little clams could not be seen, and no one knows at present where they may be found alive.

The genus *Pisidium* (the name meaning like a pea) consists of much smaller shells, the Colorado members looking like small pebbles if not closely examined. They abound in our mountain lakes; numerous species have been found, several of them new to science. Henderson gives a table of localities, twenty of them 10,000 feet altitude or over. Two or three species were found in a lake north of Corona, at an altitude of 11,500 feet. In 1887 I found a small and peculiar species in Surface Creek, on the north side of the Grand Mesa, at 8,500 feet. Unfortunately it has never been collected since, and its characters are little known.

It cannot be properly classified until someone goes to the original locality and obtains additional specimens. The figures of molluscs in this chapter are some of those used by Henderson in University of Colorado Studies, 1924, mostly taken from Bulletin 28, U. S. National Museum.

Chapter 9

INSECTS

The little people in the trees,
The villages beneath the stones,
The gaudy butterflies, the bees
That hum in gentle overtones.

All these we give to you today
To keep and hold for evermore,
To know and cherish as you may,
As many others have before.

In any book on animals, the insects should occupy a large place. Not only are they excessively numerous and varied, but we continually meet with them, and gain or lose by their presence. We lose heavily, to the extent of many millions of dollars, by their depredations on our crops. The operations of man give them new opportunities to spread and increase, so that the most troublesome pests in many localities are species quite unknown there a short time ago. The insects illustrate the balance of nature, and any species would be capable of increasing its numbers enormously, but for limitations of food supply and the attacks of its natural enemies. This balance is frequently disturbed by man, who unintentionally carries insects to new localities, where the normal checks on increase do not exist. Hence a species which is harmless in one place, may ruin the farmers in another. In consequence of these facts, we have entomological quarantine, and frequently entomologists are sent out to the uttermost parts of the earth to search for appropriate natural enemies. The citrophilus mealy-bug, which arrived in California, no one knows whence, a number of years ago, would ruin the citrus industry (with a product which in 1925 was worth over 97 million dollars), were it not kept down by an imported ladybird beetle. The discovery and utilization of this beetle is due to the work of a number of technical experts, without whose services disaster would come to a large section of the country. On the other hand, we may profit greatly by the insects; the products of the honey-bee and the silkworm, commercially valuable as they are, repre-

sent only a small part of our debt to the insect world. In recent years, the science of heredity has been made over by intensive study of a minute red-eyed fly which breeds in over-ripe fruit, the *Drosophila*. Many insects are beautiful, and charm us as do the flowers; many others have interesting habits, which Fabre, Peckham, Wheeler, Rau and others have taught us how to observe. The amateur naturalist finds among the insects materials for his collections, and opportunities for the discovery of entirely new facts. With the increasing development of ultra-technical methods, and the use of costly apparatus, we are shut off in a great measure from participating in the advancement of science. It is somewhat as if all musical instruments were abolished except the pipe-organ, all singing except that in grand opera. It would be a serious social loss, tending to lower the level of intelligence were these conditions universal. But happily it is not so with the insects. The necessary outfit costs only a few dollars, and takes little space. The species of North American insects will not be all catalogued for a very long time to come, and the possible studies of their life histories are almost infinite. Occasionally the observer will be rewarded by an important discovery, perhaps of great practical value; but at the very least he will gain much pleasure and the consciousness of personal development.

Apterygota

The most simple or primitive insects are those which have no wings, and show no signs of having had winged ancestors. The flea, bed-bug and the louse are all believed to have come from winged groups, but this is not true of the *Thysanura*, *Protura* and *Collembola*. The *Thysanura*, called Bristle-tails or Silverfish, are long carrot-shaped animals of no great size, often found under stones. There are usually three tails, and the antennae are long. The *Collembola*, also common under stones, are called Spring-tails, from their habit of leaping by the sudden extension of the furcula beneath the tail. In some, however, this furcula is wanting. They are all very small and the antennae are not very long, being usually four-jointed. Our species have received hardly any attention, and no doubt many discoveries await a keen collector. The *Protura*, very small elongated insects without

antennae, were discovered in 1907, in Italy. They are now known to be widely distributed, and probably will be found in Colorado.

Isoptera or White-ants

The name "White-ant" is a misnomer, as the insects are not ants, and are frequently not white. It is better to call them Termites, but the popular name cannot be abolished. A small species is common along the eastern foothills in Colorado. It is the *Reticulitermes tibialis* of Banks, formerly confused with *R. flavipes* of the Eastern States. The winged form is deep black. In the shales at Florissant we find several much larger fossil species, indicating a warmer climate in past times.

Neuroptera and Associated Insects

The order *Neuroptera* was formerly made to include many diverse insects, even the dragon-flies (*Odonata*). We now know that these should be distributed in several orders, but unfortunately authors do not exactly agree about their names. The Neuroptera in the more restricted sense include the Ant-lions (*Myrmeleonidae*), Lacewing flies (*Chrysopidae*) and several other groups. The ant-lions live as larvae in a circular excavation like a broad inverted cone, which they make in sandy places. When an insect comes along, they throw up sand in order to make it stumble and fall in the pit, when it is devoured. The adults look much like dragon-flies, but have conspicuous antennae. The green lacewings (*Chrysopa*) are very pretty little insects with gauzy wings and golden eyes. They lay their eggs in groups on long stalks, usually on the surface of leaves, and the larvae are very important enemies of plant-lice. We have collected about six species in Colorado, one of the commoner ones being *C. nigricornis* Burmeister, which has some of the cross-veins on the wings black or dark.

The *Plecoptera* or Stone-flies are common, the larvae living in streams. For some unexplained reason, we find no trace of them in the Florissant shales. The *Ephemerida* or May-flies also breed in water; the larvae may usually be recognized by the three tails. The adults have the hind wings small or in some

cases wanting. The Colorado May-flies have been especially studied by Dr. G. S. Dodds, formerly of the University of Colorado. About 20 years ago Miss M. Gill and the writer published an account of an interesting species, *Tricorythodes explicatus* Eaton, found near Boulder.* It is a southern insect which is just able to get through its transformations and appear late in the season at Boulder. Farther north, it probably could not succeed. The same thing is true of the dragon-fly *Archilestes*, which appears in Boulder in the fall.

The *Trichoptera* or Caddis-flies are really related to the moths, but they have hairy instead of scaly wings. The adults often come to lights at night, and the larvae may be found in little cases in the streams. These cases are of very diverse kinds, some free, others attached to stones. Some are cylindrical, with sticks, pebbles or little shells built into them. One genus (*Helicopsyche*) makes coiled cases resembling snails, and a distinguished conchologist once made the mistake of describing one of them as a new species of snail. Many Trichoptera are fossil in Colorado.

Anopleura

This group, as defined by Imms, is made to include the *Mallophaga* (Biting lice or Bird lice) and the *Siphunculata* (Sucking lice). The former are numerous on our birds, but the latter are of more importance to man, as carriers of disease germs. Dr. H. E. Ewing has recently published** a careful study of the ordinary lice of man (*Pediculus*). The head louse and the body louse have been studied by Nuttall in England, and found to hybridize. They are therefore regarded as varieties of one species. Ewing finds, however, that there are distinct varieties inhabiting respectively the negroes, orientals, and American Indians. The Crab louse (*Phthirius*) is a perfectly distinct animal, belonging to another genus.

There are other small groups of insects, not discussed here, though of considerable scientific interest.

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*University of Colorado Studies, III, (1906) p. 135. It was then placed in *Tricorythus*, but in 1923 Ulmer erected the genus *Tricorythodes* for it.

**Proc. U. S. National Museum, Vol. 68, Art. 19 (1926).

ORTHOPTERA

The crickets, grasshoppers, locusts, cockroaches, mantids and stick-insects have usually been placed in a single order called Orthoptera. The name refers to the straight upper wings of such insects as locusts, but is unsuitable for many of the other forms. In recent years, impressed by the great differences between the groups placed in Orthoptera, certain authors have proposed to recognize, not one order, but several. Whether we do this or not is of no great moment, so long as we fully appreciate the characters of the group. At the outset, we observe that some, evidently the more primitive, neither jump nor attempt any form of music. Such are the Blattidae (cockroaches), Phasmidae (stick-insects) and Mantidae (mantises)*. The other great division is characterized by enlarged hind legs, adapted for leaping; and various sounds are produced, some of which can very well be expressed in musical notation. Indeed it may perhaps be said that the grasshoppers, with their monotonous repetition of sounds, invented jazz. They were presumably the first musicians in all the world, earlier than the singing birds. There is no doubt that the jumping Orthoptera date back to the earlier part of the Mesozoic; the *Pycnophlebia* of the lithographic stone of Solnhofen in Bavaria shows very well the large jumping hind legs, and even the tympanum or hearing organ on the anterior tibiae. This was at a time when birds had many reptilian features, including teeth and a long tail bearing feathers.

Much earlier than this, however, the Blattids or cockroaches abounded. They swarmed through the forests of the Pennsylvanian Epoch, at the time when the red rocks of the Colorado front range were being deposited. In the vicinity of Fairplay, Colorado, many years ago, numerous cockroaches were found in rocks which are at least as old as the Lower Permian, and were described by Scudder. Figures are given in the Memoirs of the Boston Society of Natural History, 1890. Unfortunately this interesting discovery was never followed up, and no one knows what treasures may reward further diligent search.

Today, the cockroaches we meet with in Colorado towns

*Mr. Rehn points out that certain Mantidae (such as *Yersinia*) can really leap, and even have slightly inflated hind femora. This incipient tendency to develop saltatorial powers is of much interest, as suggesting how the leaping Orthoptera developed the faculty.

are of foreign origin. Not rarely, in bunches of bananas, we find the delicate green *Panchlora cubensis*, brought up from the tropics. The word *Panchlora* means all green. In houses the large dark *Blatta orientalis*, the too familiar "black beetle" of English housewives, and smaller and less offensive *Blattella germanica*, are not rarely observed. Yet they have never become firmly established as in Europe, and we still regard them as curiosities.

Another very ancient group is the Mantidae, those curious predatory insects with broad heads, which hold their front legs as if in the attitude of prayer. The common south European species was actually named *Mantis religiosa*. Three kinds of Mantidae have been found fossil at Florissant, while we have two small species still living in our foothill country. One of these, *Yersinia solitaria*, has the eyes sharply conical above; the other, *Litaneutria minor*, has the eyes blunt above. Both were first made known by Scudder. We also have a rather insignificant looking member of the Phasmidae, or stick-insects, the *Parabacillus coloradus* of Scudder. It is readily known from other United States species by having the antennae much shorter than the anterior femora. The name *Parabacillus* is not intended to suggest any connection with the bacilli of disease; both got the name from their resemblance to a little stick or wand, bacillum in Latin.

While the silent, non-jumping Orthoptera are so uncommon in Colorado as to be readily overlooked, it is quite otherwise with the grasshopper and cricket groups. The latter abound rather in individuals than in species, certain kinds being excessively common. The dark-colored ones are easily separated into the larger, robust forms (*Gryllus*) and the smaller *Nemobius*. The "cricket on the hearth" of Dickens is a *Gryllus*, but belongs to the domestic, house-loving species of Europe, whereas ours prefer the out-of-doors. It is interesting to note the difference between the sexes, the males having the upper wings greatly modified for musical purposes. In the Isle of Wight, England, such male wings were found fossil in rocks of Tertiary age, showing the great antiquity of the cricket's cheerful song or chirp. Even more abundant, but less often seen, are the tree-crickets, pale green or whitish, the genus *Œcanthus* of entomologists. It

was a member of this genus that Fabre studied, and charmingly discussed under the name Italian cricket. They sing at night, never tiring of performing among the bushes so long as the weather permits. When it gets cold, the songs are fewer and intermittent, and it is always with a feeling of sadness that one listens to the last cricket of summer, emitting an occasional feeble chirp. In the mountains, these crickets are totally absent above a certain altitude, and the forests remain silent except for the occasional hooting of an owl.

The long-horned grasshoppers or Tettigoniidae agree with the crickets in having long thread-like antennae. They may be separated from them by the possession of four-jointed (instead of three-jointed) tarsi; that is, there are four small joints forming the feet. Some are wingless, and such have usually been regarded by the public as crickets, and named accordingly. The so-called Mormon crickets, *Anabrus*, are bulky insects which usually occur singly, but sometimes appear in immense hordes, and do a great deal of damage. The cave crickets, *Ceuthophilus*, are often found in mines, and sometimes in houses. A very curious form, called *Tachycines asynamorus*, was found to be abundant in a greenhouse at Boulder, and was accused of eating the violets. It was in fact a visitor from Japan, accidentally brought in with plants. The large handsome green insects resembling katydids, of which we have two species common along the front range, belong to the genus *Scudderia*, which according to Caudell is more properly called *Phaneroptera*. Much smaller forms, with the head projecting in front, are called *Conocephalus* or *Xiphidium*. They abound in grassy places.

It is the short-horned grasshoppers, called Locustidae or Acridiidae,* which are the great enemies of the farmer; but whereas there are many species, comparatively few do practically all the damage. The subfamily Œdipodinae or Locustinae includes large headed insects, with the hind wings usually banded or distinctively colored. These live in dry or wild places, and are not destructive. One of the commonest, found east and west,

*If we follow Kirby in taking the large migratory locust (*Locusta migratoria*) of the Old World as the type of the genus *Locusta*, this family can be called Locustidae; but it is not correct to use Locustinae as the subfamily name for the group having a spine between the front legs. This character is found in the large migratory locusts (*Schistocerca*) of North and South America, and the Old World *S. peregrina* (probably the biblical locust) but not in *Locusta* as defined by Kirby.

is the so-called Carolina locust, *Dissosteira carolina*. The hind wings are black with a broad yellow margin, so that in flight there is a singular resemblance to the mourning cloak butterfly. Another species (*Arphia*) has the hind wings bright red, and is extremely conspicuous when flying. An English entomologist, Lord Walsingham, suggested that this fact would serve to confuse pursuing birds, because when the insect alights, the red entirely disappears. A bird having "seen red," would continue to look for it, and be unprepared to fix its mind on a totally different appearing object. It is further true that the hoppers at rest very closely resemble the soil, and where the soil is red, the hoppers have reddened varieties. In addition to this, they suddenly double back on alighting, so that they are not where we might expect them to be. I have been completely deceived by this; possibly birds are more intelligent.

In the southern and western parts of the State, as at Pueblo, Trinidad, Delta and Grand Junction, is a very large locust with the hind wings deep blue, bordered with black. This insect has a curious history. Many years ago, in the report of the Wheeler Survey, there was figured an insect called *Leprus wheeleri*, with pale yellowish hind wings. No one found such locusts, but instead the blue-winged species, which seemed in general to agree with the one figured. The difference of color in the wings was supposed to be due to fading, or the influence of a preservative. So the matter remained, until one night I happened to be in the streets of Roswell, New Mexico, and saw some of these locusts under the electric lights. I idly picked one up, and opened the wings to see the blue color, but to my astonishment it was not there. I had found the real *Leprus wheeleri*, looking exactly like the original picture, not only as to the color of the hind wings, but also in the pattern of the upper pair. The blue-winged locust was accordingly given a new name, *Leprus cyaneus*.

Another genus, *Circotettix*, common in the mountains, is easily recognized by the noise made in flight. A popular name, castanet grasshopper, is so characteristic as to lead to instant recognition.

The lubber grasshopper, *Brachystola magna*, often found near the eastern base of the mountains, is exceedingly bulky,

varying from 43 to 61 mm. in length. The wings are vestigial, represented by rounded, speckled pads. It would seem as if Nature had abandoned the attempt to support such a heavy insect in the air. The curious thing is, that this type of evolution has occurred more than once, for the equally large lubber grasshopper of the southern states, *Rhomalea*, has a spine between the front legs, and belongs to the next subfamily.

The subfamily Acridiinae or Cyrtacanthacrinae* (Locustinae of Comstock's Introduction) is easily recognized by the possession of a conspicuous obtuse spine on the prosternum, between the bases of the front legs. It is to this group that some of the large migratory locusts belong. Discussions arise as to the precise meanings of the words locust and grasshopper. Actually there is no difference, except that it is common to call species which are either large or destructive locusts. The migratory locust of historical fame is quite large, but the Rocky Mountain locust is really an ordinary-looking grasshopper, which became a locust in popular estimation because of its ravages. This migratory insect, called *Melanoplus spretus*, was first described in 1865, and its migratory hordes did so much damage in the Western States that a special Government Commission was appointed to study it and devise remedies. The swarms, appearing like dark clouds, were capable of travelling as much as 500 miles from the point of origin, and when they descended, they made short work of the crops. In spite of these invasions, the locusts did not permanently establish themselves in the localities they reached, and when the breeding grounds in the Dakotas, etc., were for the most part plowed up and put into cultivation, the swarms became a matter of history. It is safe to say that no invasion of the Rocky Mountain locust will ever occur again, and indeed Professor Gillette of the Colorado Agricultural College said in 1904 that during 13 years of collecting, during which he had obtained enormous numbers of grasshoppers, he had failed to find a single specimen. In fact, no resident of Colorado has taken a *Melanoplus spretus* in recent years, so far as I can learn; supposed specimens always seem to

*Rehn and Hebard use Cyrtacanthacrinae for Acridiinae of authors, Acridinae for Truxalinae of authors, and Acrydiinae for Tettiginae of authors. All these they place with Oedipodinae in a family Acrididae.

be the closely related but very common *Melanoplus atlanis*, a permanent resident of Colorado. Nevertheless, Mr. Morgan Hebard of Philadelphia records finding specimens of *M. spretus* in the Garden of the Gods and at Mountain View, Pike's Peak, in August, 1904; but whether they had bred in the locality he was unable to determine. In *M. atlanis* the tegmina or upper wings are about 20 mm. long in both sexes; but in *M. spretus*, as befits a migratory species, they are considerably longer, about 26.5 mm. in the male, and 27.5 in the female. Both species have the hind tibia red, except that in *atlanis* variations occur in which they are blue (variety *caeruleipes*) or pale yellow. These variations are interesting, because they show that the Acridiinae have pigments in their legs similar to those found so conspicuously in the Œdipodinae.

The resident *M. atlanis**, and other species of the same genus, do a great deal of damage to crops every year, but do not cause sudden and dramatic castatrophe in the manner of *M. spretus*. The numbers of these insects vary in different seasons, and recently the entomologists of the U. S. Bureau of Entomology have been making intensive studies of the early stages, in order to recognize the unusual abundance of any injurious species while it is young, and can be controlled by poisons before any serious damage has been done. This involves minute and discriminating studies, for several of the kinds are very much alike.

A much larger *Melanoplus*, about 27 (male) to 37 (female) mm. long, very common in Colorado, is *M. bivittatus*, described by Say in 1825. It is easily recognized by the pair of yellowish stripes running along each side of the thorax above, extending forward on to the head above the eyes, and backward on to the tegmina, where they converge when the wings are closed. A further distinguishing mark is the broad, continuous black stripe along the outer side of the thickened hind femora. On account of its large size and abundance, this yellow-striped locust is likely to be particularly troublesome, and Professor Gillette expressed the opinion that it was the most injurious species in Colorado. It will attack alfalfa, clover, grass, corn, vegetables, and in fact

*Hebard has proposed to reduce *M. atlanis* Riley to subspecific rank under *M. mexicanus*. It has also been maintained of late that *M. atlanis* and *M. spretus* are forms of a single species. The name *mexicanus* is the oldest (1861), then *spretus* (1866), then *atlanis* (1875). Hence we should have to write *M. mexicanus spretus* for the Rocky Mountain locust.

almost any cultivated plant. Thomas Say found this species on Long's Expedition, and says of it: "This species, with several others, occurred in great numbers near the mountains, and on one occasion we observed this species in company with several others, ascending to a great height in the air as if to commence a migration to a remote region." In his description, he said the posterior tibia were green, pale toward the tip and on the anterior side. They are very commonly darker than this would imply, practically lead-color. In the Atlantic and Pacific States, and across Canada, this insect is represented by a locust with red hind tibiae, but otherwise not materially different. Specimens of this red-legged species have been reported from Wyoming and Colorado, but they are certainly extremely rare in Colorado. The red-legged yellow-striped locust is called *Melanoplus femoratus*, named by Burmeister in his Handbook of Entomology, 1838. Blatchley, in his account of the Orthoptera of Indiana, states that *M. bivittatus* will mate with *M. femoratus*, and he has found various specimens intermediate between the two supposed species. He therefore considers *femoratus* a synonym, but it agrees exactly with the definition of a subspecies, and should accordingly be called *M. bivittatus femoratus*.

Another large and destructive species, found especially at lower altitudes, is the *Melanoplus differentialis* of Uhler. The females may be over 40 mm. long. This lacks the conspicuous stripes of *M. bivittatus*, and the hind femora are variably marked with black in the form of transverse bars. An exceedingly dark (melanic) variation occurs (variety *nigricans*); as it is found in the same localities as ordinary specimens, it is presumably a mutation, showing Mendelian inheritance.

The harlequin grasshopper, *Dactylotum pictum* of Cyrus Thomas, is almost described by its popular name. It is only of moderate size (females reach about 35 mm.) and has short wing-pads, without functional organs of flight. The body is dark, variegated with bright red in harlequin fashion. Two pale stripes run down the middle of the face. Another interesting genus, likely to be met with on the plains, is *Hesperotettix*, the name meaning western grasshopper. The species are of medium size, green, often with pretty markings. In the common *H. viridis* of Thomas, the thorax above has a median white stripe

edged with blackish, and the hind femora have a red garter-like band near the end. In *H. speciosus* of Scudder the thorax above appears to be slightly keeled, the keel having a rosy tint. The tegmina are short but still functional; in *H. viridis* they are very well developed. *H. speciosus* was found in numbers at White Rocks, Boulder County, feeding upon the horse-weed, *Cyclachaena xanthiifolia.** On the wild sage brush (*Artemisia*) at low altitudes one may find the curious little *Hypochlora alba* of Dodge, pale like the sage, a sort of whitish green, and quite unable to fly. It is interesting to note that certain Orthoptera are confined to one genus of plants, while others are polyphagous, feeding on many.

ODONATA

The Odonata, or dragon-flies, are recognisable by the more or less slender body, and four membranous, finely netted, wings. Sometimes they may be confused with the Ant-lion-flies, but the details of the wing venation are different, and a glance at the antennae will be decisive. The antennae of the dragon-flies are so short that they seem to be absent on hasty examination, while those of the ant-lion-flies are always conspicuous. The immature stages of dragon-flies are passed in the water, and exhibit some very remarkable characters. The labium or lower lip is greatly enlarged, forming a peculiar structure called the mask, which fits over the face, and can be extended to grasp the prey of this predatory insect. The details of the structure of this mask differ in the various groups of dragon-flies, and are used as a means of classification. The immature dragon-fly has been rather absurdly called the nymph, for it has neither beauty or elegance. Comstock has recently proposed to use the term naiad, but this is inadmissable, because it has long ago been applied to the fresh-water mussels. Thus Lea in 1829 published a "Description of a New Genus of Naiades," and Simpson, in 1900, published a "Synopsis of the Naiades, or Pearly Freshwater Mussels." Tillyard, with some reason, argues that the simple and obvious thing to do is to speak simply of the larva, whether old or young, as there is no distinctly differentiated pupa stage in these insects.

*Rydberg writes this *C. xanthifolia;* but the name means with leaves like those of a cocklebur (*Xanthium*), and so should be *xanthiifolia.*

The dragon-flies of Colorado are easily separated into two great groups or suborders, the Anisoptera and Zygoptera, the latter being often called damsel-flies. The Anisoptera, or dragon-flies proper, are usually larger and more robust, with more powerful flight, and the hind wings are more or less broadened at the base, in some species forming a prominent angle. When at rest, the wings are carried horizontally, as in flight. In the damsel-flies the body is slender, and the wings taper to the base, the anterior and posterior ones being very much alike. With very few exceptions, the wings are held backward over the abdomen in repose. The larvae of the Zygoptera are known by the three conspicuous appendages, sometimes leaf-like, known as the caudal gills. Their importance for respiration is not altogether evident, as when several larvae are confined together, they will eat each other's appendages, and individuals thus mutilated go on living. It has generally been assumed that of the two suborders, the Zygoptera are the older, on the ground that the first flying insects doubtless had two pairs of wings alike. But as Tillyard points out, the very ancient primitive dragon-flies known from fossils, in some cases over two feet across the wings, were evidently powerful flyers, with a build suggesting the Anisoptera, not at all the damsel-flies. A very beautiful Eocene fossil (*Eodichroma mirifica*) recently discovered in Texas has very broad wings, yet from its structure is evidently one of the Zygoptera. Thus it seems reasonable to suppose that the principal features of modern damsel-flies are not really primitive, but represent an adaptation to their special mode of life.

Fossil dragon-flies are found in Colorado both in Eocene and Miocene rocks. The most interesting and remarkable form, which has been exhaustively discussed in a memoir (Proceedings of Philadelphia Academy, 1913) by Calvert, is the genus *Phenacolestes* from Florissant. This is one of the Zygoptera, and the wings found are some of them almost perfectly preserved, showing the dark cloud across the apical half. A striking feature, in which it differs from most of its near allies, is the presence of several antenodal cross-veins. These are the little cross-veins from the upper edge before the slight depression (at the end of the arched part) known as the node. This is thought to be a primitive character, and is found also in a genus from the Eocene rocks of

Wyoming. The modern damsel-flies of the same group or subfamily have only two of these antenodal cross-veins, with the exception of three rare genera, found in Central America, Ecuador and West Africa respectively.

Although the living Colorado Zygoptera are for the most part small and rather inconspicuous, there are two very beautiful species. One of these, described by Kennedy as a "living jewel with its metallic green body and crystal wings tipped with jet", is the *Agrion aequabile* of Say. In the males the wings are broadly black at the end, as if dipped in ink; in the females this color appears as if diluted, becoming pale brown. The antenodal cross-veins are numerous, as in all members of the Agrionidae (Calopterygidae of many authors). This splendid insect occurs in the mountains not far from Boulder, and the Colorado specimens differ from those obtained in other parts of the United States, so that they are recognized as a subspecies *coloradicum*.

The other conspicuous damsel-fly found in Colorado is the *Hetaerina americana*, first described by Fabricius* in 1798. Both sexes were collected by Mr. Glenn Hite at Pueblo, in August 1907. The female has the wings slightly stained with rusty reddish, but is not at all striking. The male has the bases of the wings broadly brilliant carmine, the color of red ink, and the head and thorax have a beautiful copper-red suffusion. This insect looks tropical, and is in fact a northern representative of a genus which abounds in Central and South America. This particular species has a very wide range, from Canada to Guatemala. *Hetaerina* belongs to the Agrionidae, and, like *Agrion*, has many antenodal cross-veins.

There is a very fine genus of damsel-flies called *Archilestes*, large forms with only two antenodal cross-veins, represented by two species in North America. In the fall of 1921 this genus was discovered at Boulder, in the immediate vicinity of the University, by Miss Dorothy Young. So far, only females have been collected, and the identity of the species is therefore uncertain.

Our Anisoptera include numerous species, some of them of

*John Christian Fabricius, 1742-1807, was a professor in Copenhagen, Denmark. Following the methods of Linnaeus, he described insects of all kinds with the utmost zeal, traveling to foreign countries to examine collections. Dru Drury, the English entomologist, described him in 1768 as "a very ingenious worthy young gentleman of Denmark", and in 1773 wrote: "He is now in London and very busy in making descriptions . . . . . a pleasure he seems to enjoy with as much glee as a Lover of Wine does ye sight of his Cellar when well stored with full Casks and Bottles."

large size. The very large ones, often nearly three inches long, seen flying over ponds, belong to the genus *Aeshna*. The wings are clear and transparent, but the body is prettily marked with green or light blue, the colors unfortunately difficult to preserve after death. Because of their powerful flight, some of the species of *Aeshna* have become very wide spread; thus *A. juncea* of Europe is also found in Colorado; *A. palmata*, originally described from Kamchatka, has been collected at Twin Lakes. It used to be supposed that we had little to learn about these common and conspicuous dragon-flies, but this was due to taking things for granted, without proper investigation. In the summer of 1906 Dr. E. M. Walker of Toronto was at Lake Simcoe, Ontario, and seeing the species of *Aeshna* in unusual abundance, began to interest himself in their structural characters. To his astonishment and that of other entomologists, he discovered that there were several kinds which had been overlooked and confused with those previously described. The final result was the publication by Dr. Walker (1912) of a Monograph of North American *Aeshna*, one of the best studies ever made of a group of insects. Dru Drury, goldsmith, of London, (1725-1804), was a pioneer among amateur entomologists. For many years he did everything in his power to secure specimens of all orders, from every accessible part of the world. We find him writing to a correspondent in Virginia (1770), "Insects are my darling pursuit, therefore any that come under that denomination either large or small will meet a hearty reception." In 1767 he was writing to Mr. Thomas James of New York, urging him to obtain dragon-flies, and telling him how to rear them from the larvae. "Get a large Buckett, pail or washing tub, and put in it some weeds that grow in ye water, fill it three parts full with water, and in ye spring search ye waters above mentioned for Insects and put in as many Libella cats as you please. Be sure to put in a great many of ye small sorts, because ye large sorts prey and feed on ye small ones as you will have opportunities of observing. If you find the number of small ones decrease very fast you must supply the tub with fresh ones, and once in three weeks or a month change ye water. You must make a contrivance of a frame covered with gauze to go over ye Buckett or Tub so that when ye Libellas are bred they cannot fly away." The result of all this effort was that

Drury received some of the finest North American dragon-flies, at that time entirely new to science. So we find at Boulder *Plathemis lydia* of Drury, in the male of which the wings are very broadly dark reddish brown in the middle, but clear at either end, except for an elongate basal stripe, in which is a small more or less transparent central area. Then we have from Florissant (taken by Mr. S. A. Rohwer) Drury's *Libellula pulchella*, each wing with three dark brown patches, one at the base, one in the middle, one at the tip, while between them are chalky clouds. The white clouds may be absent in the female. The female of *Plathemis lydia* is smaller than that of *L. pulchella*, the hind wing about 33 mm. long (over 40 in *L. pulchella*), but the wing markings are almost as in *L. pulchella*. The median dark patch of *P. lydia* sends a pointed projection from its inner side, and as there is another process near the upper margin on the outer side, the whole patch has rather the outline of the head of some woodpecker. The genera *Plathemis* and *Libellula* are in fact extremely closely allied, and according to a recent (1922) revision by Kennedy, *Plathemis* is to be regarded as a subgenus of *Libellula*, instead of a full genus. For species of the type of *L. pulchella* he proposes a subgenus *Neotetrum*. A second species of *Neotetrum* is *L. forensis* of Hagen, in which the ends of the wings are clear. According to Kennedy, *L. forensis* will breed in alkali ponds, but *L. pulchella* breeds only in strictly fresh water. A specimen of *L. forensis* was taken by Mr. F. W. Rohwer at Boulder. It not only lacks the dark tips to the wings, but the median patch is enlarged and irregularly dumb-bell shaped.

There are still other species of *Libellula* in Colorado. The *L. quadrimaculata* of Linnaeus, which is not uncommon, has the wings clear except for an orange suffused area at the base, bounded below by black on the hind wings, a small spot at the nodus, and the long dark pterostigma near the end of the wing. The black area at the base of the hind wing has a triangular expansion, on which the veins appear white. This species, found in the Old World from England to Japan, is not related to any other American form, and is surmised to be a comparatively recent immigrant from Asia. Another *Libellula*, taken at Pueblo by Mr. Glenn Hite, and kindly determined by Dr. Calvert, is the *L. saturata* of Uhler. It is large, the hind wing about 40 mm. long; the body is

rather pale reddish, with a white line down the middle of the thorax; the wings are without dark markings, but suffused with yellowish-red, the pterostigma also being of this color. This very distinct-looking species falls in the subgenus *Belonia* of Kirby, a group of the Central American highlands, with one species extending up the Rocky Mountain chain. The genus *Tramea* includes some large strong-flying species. *T. onusta* of Hagen, which Mr. E. Bethel has taken at Denver, has the broad base of the hind wings brownish-black, the wings being otherwise clear, with a short pale orange-brown stigma. There are large light areas on the abdomen. This is a widely distributed dragon-fly, extending to Central America and Cuba; it represents an extension of a tropical group into the Rocky Mountain country.

The genus *Sympetrum* consists of modern sized species, the wings usually about 25 to 30 mm. long. Some of the forms have the basal half of the wings rust color or pale reddish, in others the wings are quite clear. A female of *S. corruptum* was taken on Arapahoe Peak (13,000 ft.) by Mr. E. Bethel in 1914, and Dr. Calvert remarked at the time that this was probably the highest recorded altitude for any dragon-fly in the world. *S. danae* of Sulzer (*scoticum* of Donovan), determined by Dr. Calvert, was taken by Mr. Hite at Gresham Lake in Boulder County, September 1907. This species extends all around the world in northern regions, and is common in the British Islands.

HEMIPTERA

The order *Hemiptera*, or Plant-bugs and their relatives, is divided into two suborders. In the *Heteroptera* the upper wings are largely more or less hard and opaque, like the elytron of a beetle, but the apical part is membranous. In the *Homoptera* the upper wings are of the same consistency throughout. All have sucking mouth parts, except that adult male Coccidae have no mouth; and the metamorphosis is incomplete, though approaching the complete type in male Coccidae. Although the Coccidae or scale insects seem to approach in their transformations the series of higher insects which Imms calls Endopterygota,* they are in fact a specialized group, leading to nothing beyond.

*The Endopterygota, or Holometabola, include such insects as the Lepidoptera, Hymenoptera, Diptera, Coleoptera, etc., which have a definite pupa stage. They are the "higher", or more specialized insects. But Mecoptera and Neuroptera date back to Permian times, and are thus of vast antiquity. Tillyard has even described (1924) Permian beetles from Australia.

Heteroptera

Entomologists call these the "true bugs", but perhaps without sufficient warrant. The original meaning of the word bug was a demon or source of terror, and we still have the words bugbear and humbug in the English language. In America, the popular use of bug is inclusive of almost any arthropod; in England, it is usually restricted to the bed-bug. It is therefore prudent for Americans visiting England to refrain from the use of the word, and even here it is not altogether free from a flavor of slang.

The family Pentatomidae, with many common species, is usually known by the very broad body and large triangular scutellum. Some kinds are highly injurious, but others are beneficial to man, preying upon injurious insects. One of the latter, *Perillus claudus* of Say, attacks cutworms and larvae of various beetles, and is said to be an efficient enemy of the Colorado Potato Beetle. It has two forms, one yellowish, the other reddish, in each case with dark markings.

The Coreidae include the large dark Squash Bug (*Anasa tristis*, or more correctly *Oriterus tristis*, Hahn's generic name *Oriterus* having priority, and having a definite type). It is about 16 mm. long and has a strong but rather agreeable odor. A very familiar form is the Box-elder Bug (*Leptocoris trivittatus* of Say), which feeds on box-elder trees, and often comes into houses in the fall. It is rather narrow, black, with red markings. The young are bright red. The black membrane of the anterior wings is finely striated, a feature which at once distinguishes it from the rather similar species of *Lygaeus* (Family Lygaeidae). A very common species of the latter group (*Lygaeus reclivatus* of Say) has considerably more red than the *Leptocoris*, and there is a white spot on the membrane. The true Chinch-bug (*Blissus leucopterus*), so injurious to wheat, seems not to occur with us. Essig remarks that although it occurs in the west, it does little damage there. As a matter of fact, the native Rocky Mountain species is distinct, and has been called *Blissus occiduus* by Barber (1918), the type being from Fort Collins. The Ambush-bugs (*Phymata*, of the Family Phymatidae) are yellow with darker markings, and are found on flowers, where they prey on bees and other insects. The front legs are extraordinarily modified for clasping their prey.

The Bed-bug (*Cimex lectularius*) is not our only member of the Cimicidae. Other species of this wingless flattened type prey on bats and birds. The latest addition to our fauna is *Hesperocimex coloradensis* of List, found in a house in Colorado Springs.

The species of Miridae are extremely numerous, but small and inconspicuous. The commonest and most wide-spread is the Tarnished Plant-bug (*Lygus pratensis* of Linnaeus), about 6 mm. long. Every collector of insects finds it among his first captures.

The aquatic Heteroptera include the Gerridae or Water-striders, which run in a jerky fashion on the surface of the water, the Back-swimmers (Notonectidae) which swim upside down, propelled by their long oar-like legs, the Water-scorpions (Nepidae), the Giant Water-bugs (Belostomatidae) and others. Those living in the water have minute concealed antennae, and hence are called Cryptocerata, the word meaning hidden horns. The Giant Water-bugs are sometimes destructive to young fish. Although these aquatic Hemoptera are highly modified insects, they were well developed in Colorado as early as the Miocene, fossils having been found in the Florissant shales.

Homoptera

Our largest Homoptera are the Cicadas (Cicadidae), often mistakenly called locusts. Mr. W. T. Davis has published (1921) a list of the Colorado species, including 23 living and three fossil. Although these insects are large and conspicuous, and attract our attention by their calls, they usually sit high up in the trees, and are not easily collected. Hence it has happened that the Colorado species were for a long time little known, and of the 23 species, no less than 12 have been made known in quite recent years by Davis. There is a very large wasp (*Sphecius*) which preys on Cicadas, carrying them to its burrows. Dr. F. E. Lutz tells me that he finds it a good plan to watch for these wasps, and deprive them of their prey, thus securing specimens which otherwise are out of reach. The voices of the different Cicadas are recognizable by experts, being perhaps as distinctive as bird-calls. There is a species which I heard at Tsuruga, Japan, the call of which is so like that of a bird that most people are deceived until they see the insect. One of our common species, a rather small one, is

named *Platypedia putnami*. J. Duncan Putnam was a brilliant young entomologist, who came out to Colorado from Davenport, Iowa, in the hope of recovering from tuberculosis. He discovered *P. putnami* on some aspen trees by Clear Creek, between Floyd's Hill and Idaho Springs, July 2, 1872. Although his life was cut short, his Cicada still sings in the trees along our mountain creeks, and serves to remind us of him. Lutz describes the song as a clicking sound, about eight clicks, rapid at first, but slowing. The genus *Platypedia* has long existed in Colorado, a species (*P. primigenia* Cockerell) having been found fossil at Florissant.

The Cercopidae, popularly called Spittlebugs or Froghoppers, are stout small insects, the larvae of which live on plants, and are covered by a mass of white froth. They are common on herbaceous plants in gardens. A common species in Boulder is the *Aphrophora irrorata* of E. D. Ball. It is nearly half an inch long, speckled with gray and whitish, and with patches of rusty red. It was first described as recently as 1898.

The Membracidae, or Tree-hoppers, often assume grotesque shapes, and are especially abundant in the tropics. We have a few noteworthy species, such as the Buffalo Tree-hopper (*Ceresa bubalus*), which is green and wedge-shaped, the anterior end very broad and thick, with a sharp spine at each corner. I have found it on sunflowers. A related species (*C. basalis* Walker) is smaller, and black beneath.

The Fulgoridae, now divided by authors into a series of families, are inconspicuous members of our present fauna, but in Eocene times they were abundant, many of them with broad, prettily marked wings, looking like moths. They have been found fossil in the oil shales of Western Colorado. Such moth-like forms are common today in India and other tropical countries. The Cicadellidae or Jassidae abound everywhere, but are never large. Some are very injurious to cultivated plants. The Sugar-beet Leaf-hopper (*Eutettix tenellus* of Baker) is a small greenish or yellowish white insect, which seems to hop, but really flies when disturbed. It is the cause of great losses to the growers of sugar beets, but for some reason is not especially harmful in Colorado. It carries the organism of the curly-top disease, whereby the leaves become crumpled and other serious symptoms appear. Stevens (1921) estimated that the total loss from curly-top during

the previous sixteen years was not less than sixteen million dollars. The Clover Leaf-hopper (*Aceratagallia sanguinolenta* Provancher) is a broader and shorter insect, which also occurs on sugar-beets, and sometimes seriously damages the small plants. It is also a pest on clover and alfalfa. The Grape Leaf-hopper (*Erythroneura comes* of Say) is an extremely small species which is frequently abundant on Virginia Creeper, causing the leaves to wither. The Chermidae or Psyllidae, the so-called Jumping Plant-lice, are all small, with delicate wings. Many years ago, I had a capsicum pepper plant growing in a pot in my house in Boulder. Presently I noticed some insects upon it, and on examination they proved to be a species of Chermidae which could not be identified. I sent some to Karel Sulc of Bohemia, and he described the insect as *Trioza cockerelli* (1909). Later on, D. L. Crawford placed it in a new genus, which he called *Paratrioza*. We now find that this insect is wide spread in the west, occurring on various plants, but seriously injurious to those of the potato family, such as the tomato. In California there are three broods in a year, so it multiplies very fast. Essig calls it the Tomato Psyllid, and gives a good figure.* A species of this family (*Pachypsylla rohweri* Cockerell) produces galls on the leaves of hackberry about Boulder.

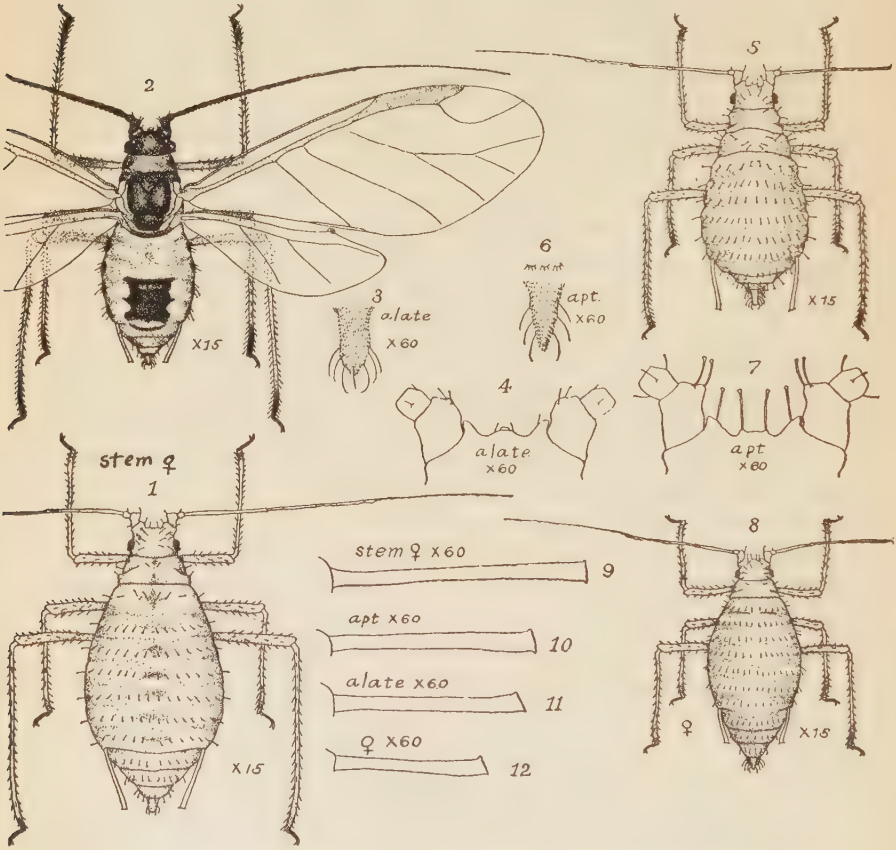
The Aleyrodidae or White-flies are often seen in greenhouses, but also occur out of doors. The immature stages resemble small oval scale insects, and often have a white fringe. The adults are very small, with four white wings, which in some kinds have dark markings. *Tetraleurodes ursarum* Cockerell is found on the bear berry or kinnikinnick. *Trialeurodes ambrosiae* Cockerell occurs on leaves of a common weed of the genus *Ambrosia*. In this, the wings are spotted with gray.

Aphididae or Plant-lice

Professor C. P. Gillette, Director of the Colorado Agricultural Experiment Station, has long been known as one of the leading students of Aphides or plant-lice. Owing to his researches, the Colorado species are comparatively well known. In October, 1925, he informed me that he knew of 243 species occurring in our State. Although some are serious pests, many feed only on

*Insects of Western North America, (1926) p. 219.

wild plants in the mountains, and are not regarded as harmful. Many live on conifers, and have recently been made known with beautiful colored illustrations by Professor Gillette and Miss M. A. Palmer.* *Tamalia coweni* Cockerell produces red galls on the leaves of kinnikinnick and on the related manzanita in California. Species of *Pemphigus* and related genera make galls on poplar or cottonwood trees; one of the commonest is *P. populi-*



Plant Lice (*Myzus ribis* Linnaeus) after Gillette, Journ. Economic Entomology 1917. Much enlarged. This species is injurious to currants. Drawn by Miss Palmer

monilis Monell on narrow-leafed cottonwood. *Gillettea cooleyi* Gillette makes galls on silver spruce, and migrates to the Douglas

*Annals Entomological Society of America, XVII. (1924) No. 1.

fir. It is usually placed in the genus *Chermes*, but Borner proposed the genus *Gillettea* in 1909. There are other related forms on different conifers. *Brevicoryne brassicae* Linnaeus is the grayish-appearing aphis so common on cabbage. It has been introduced from Europe.

The Woolly Aphis of the apple (*Eriosoma lanigera* Hausmann,) abounds on apple trees in many places, and is conspicuous because covered with masses of wool-like wax. A related species (*E. americana* Riley) migrates between the elm and the apple; but still another (*E. ulmi* Linnaeus) migrates between elm and currant. The migrations of certain aphids are very remarkable. After living and multiplying for a time on a certain plant, at the proper season of the year they suddenly take flight, and go off to some quite different host-plant. Thence they, or their descendants rather, eventually return to the original host. Professor Gillette points out that these plant-lice are attacked by many enemies, Syrphid flies, Lacewing flies, Ladybird beetles, small Hymenopterous parasites, etc. These rapidly increase, and might exterminate the aphids, did not the latter suddenly depart, leaving their tormentors behind. While the aphids thus have many enemies, they also have friends. These are the ants, to which they afford nourishment. The ants approach them, and from the tail end they exude drops of liquid, which are greedily lapped up. I have seen aphids on a branch, attended by ants. Small wasps came to take the aphids as provision for their nests. The ants would rush at them, as a bulldog rushes at a burglar, and usually succeeded in driving them away. Once in a while, however, the wasp got an aphid. There are some aphids which live under stones, in nests of ants. In 1908, Rohwer described two species found in nests of ants under stones in Boulder. One of these (*Forda olivacea*) has since been found to be wide spread and injurious to the roots of grasses and cereals.

Macrosiphum rosae Linnaeus is the common green or pinkish plant louse found on cultivated roses, with which it has been introduced into this country. *M. albifrons* Essig is a large species found on lupines; it was taken on the University of Colorado campus. *M. rudbeckiae* Fitch is the red aphid found on goldenglow in gardens, and the wild *Rudbeckia* in the mountains.

The Water-lily Aphis (*Rhopalosiphum nymphaeae* Linnaeus)

is found on aquatic plants, but migrates to almond, apricot and plum. *R. grabhami* Cockerell is found on *Lonicera*, and was described from New Mexico, but Mr. L. C. Bragg found it at Eldora, Colorado. The Green Bug (*Toxoptera graminum* Rondani) is very injurious to cereals, and is reported by Gillette as causing trouble in the vicinity of Boulder. *Cerataphis lataniae* Boisduval is a very curious aphid, resembling a scale insect, found on the orchid *Cattleya labiata* in a greenhouse in Boulder. The Dogwood or Sunflower aphis (*Aphis cornifoliae* Fitch) migrates between dogwood (*Cornus*) and Sunflower. The Grindelia aphis (*Atarsos grindeliae* Gillette), infesting gum-weed, is very remarkable for the absence of the tarsi, the terminal portions of the feet.

Many aphids have been found fossil at Florissant, causing us to marvel at the preservation of such minute and delicate objects.

Scale Insects and Mealy-bugs (Coccidae)

The casual observer, passing through the country, is not likely to notice the small sedentary insects called Coccidae. If he is observant, he may see the white ovisacs of the cottony maple scale (*Pulvinaria innumerabilis*) on maples and box-elder trees in the towns. On close inspection of these, he will find that the female insects are oval and scale like, but at maturity secrete a great quantity of material consisting of waxy threads in which the eggs are enveloped. This material constitutes the ovisac, and looks like a tuft of white cotton. It readily adheres to any passing object, and there can be no doubt that the scales are spread from tree to tree through the agency of birds, to the legs of which the waxy secretion, containing the eggs, readily becomes attached. The young scale insects, on hatching, are seen to be minute objects with short antennae and six legs. They crawl about for a short time and then, in the case of the majority of species, settle down to a sedentary life, permanently fixed to some point on the tree or shrub which they inhabit. The mealy-bugs and similar forms, however, remain capable of locomotion all their lives.

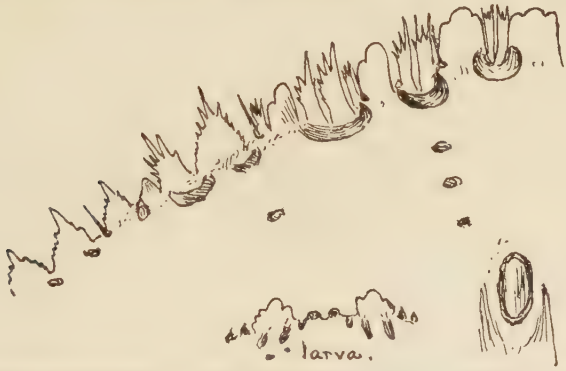
Scale insects are very interesting to the biologist on account of their peculiar structure and habits. Certain of them are more than interesting to the horticulturist, for they destroy his trees.

They are, in fact, among the most dangerous of all insects, and very large amounts of money are annually spent in destroying them, or in the effort to prevent their further spread. After this statement, it may sound alarming to say that there are numerous species native in Colorado, but actually these native species rarely do any serious damage. The introduced kinds, accidentally brought in on plants, are the ones which ruin the orchards. These are the species which specially feed on our cultivated trees, and which, away from their native home, are also away from most of the natural enemies which would keep them in check. In 1908 Mr. T. B. Holman brought me some twigs from a Japanese quince received at Boulder, but not yet planted out. Microscopic examination showed that they were infested by the San Jose Scale (*Aspidiotus perniciosus* of Comstock). This scale is really a native of Asia, but it was accidentally introduced into California, and was first noticed at San Jose, whence the popular name. It has spread right across the country, on deciduous fruit trees, doing enormous damage. An infested orchard shows dead and dying trees, which seem to be covered with a sort of gray scurf. Thus it will be understood that the keen eyes of the inspector, detecting the pest before the imported trees were planted, saved the orchardists tribulation and expense, to a greater extent than most of them realize. Some years ago I received a piece of twig from a correspondent in Argentina, with a letter asking the name of the scales infesting it; they were new to Argentina. The insect was the San Jose Scale, and I hastened to write urging that every effort should be made to prevent the spread of such a pest. When recently in that country I learned that it had spread far and wide, and was now considered one of the permanent enemies of the fruit grower. So far, we are more fortunate in the vicinity of Boulder.

The more highly specialized scale insects, such as the San Jose scale, seem to contradict the definition of an insect, and also that of the order Hemiptera, to which they belong. The adult females are without legs and practically without antennae, though they have large mouth-parts, adapted for sucking the sap out of the trees. The adult males, which last only a short time and are rarely seen, are totally different. They are small fragile creatures with a single pair of wings, six legs and long antennae,

but no mouth parts. They take no nourishment after reaching the adult stage. In the case of the San Jose scale and its relations (Diaspidae), the female secretes a waxy scale, under which it lives, like an oyster in its shell. Other species form a scale consisting of their own hardened bodies, still others envelop themselves in a dense covering of wax, while some mealy-bugs have only a thin powdery secretion of wax on the surface of the body. The wax scales are common in warm countries, but one species (*Ceroplastes irregularis*) comes as far north as Colorado, living on the shrubby *Atriplex canescens*. Small mealy-bugs, of several genera, are very common under stones in nests of ants (*Lasius*). They feed on roots of grass and other herbaceous plants, and are carefully tended by the ants for their sweet secretions. When the nest is disturbed, the ants carry the mealy bugs away into their galleries for safety. To collect these ant-nest Coccidae, it is necessary to examine the nests in the spring, for later in the year both ants and coccidae have gone under ground, and are not easy to find. One interesting species is the native cochineal (*Dactylopius confusus*). Masses of white material will be seen on prickly-pear cactus (*Opuntia*), and when this is pulled apart, the red stain of the insects themselves will be seen. Although this is a true cochineal, it is not and never has been of any commercial value, the insects being much too small to be worth gathering. A common native species, which extends across the plains to Wray, on the eastern border of Colorado, is *Amonostherium lichtensioides*, forming round white sacs, on sage-brush (*Artemisia*). Narrow white scales on leaves of pine trees in the foothills are *Chionaspis pinifoliae* of Fitch. Lift one up with a pin, and the eggs will often be seen beneath. Broader white scales on the bark of willow and poplar are *Chionaspis bruneri*. The so-called oyster-shell scale, better called mussel scale, is very small, dark brown, tapering at the anterior end. It was introduced from the Old World, but is widely spread in America. The name used for it is *Lepidosaphes ulmi* (Linnaeus), but it has been shown by various workers, and in great detail by Miss Grace H. Griswold in a recent (1925) publication of Cornell University, that there are really two distinct forms. The form which particularly infests apple trees has a uniform brown scale, but that found on lilac has the scale cross banded with a paler color. The female insects themselves agree

in essential structure, but the lilac form has on the average more gland-pores. Thus we have the insects in a very early stage of evolution, on the way to become recognizably distinct species. The matter is of practical importance, because while the lilac form infests many kinds of trees and shrubs, as ash, poplar, aspen and willow, it does not feed on apple. When specimens of the lilac form were artificially transported to apple and pear, they



Aonidie pseudaspidiotus. Caudal end of female and larva. Highly magnified.

could not survive. It is the lilac form which exists in the Denver parks, and was found by R. L. Shotwell on willow near Boulder. Miss Griswold does not attempt to settle the proper names of the two forms, but it is highly probable that the lilac form is to be called *Lepidosaphes ulmi*, and the apple form *L. pomorum* (Bouché) or *L. ulmi pomorum*. The only uncertainty relates to the precise characters of the European form on elms, which has not been reinvestigated in recent times.

Many interesting scale insects, some of them of tropical origin, may be found in greenhouses.

COLEOPTERA OR BEETLES

When, in 1887, I announced to my friends and relatives in England that I was leaving for Colorado, the nearly universal comment was: "then you'll see the beetle!" The Colorado potato beetle, thus famous across the water, is the *Leptinotarsa decemlineata*, discovered by Thomas Say on Long's Expedition. It was observed to feed on the wild yellow flowered spiny Buffalo

Leptinotarsa decemlineate Woods Hole, Mass. Evelyn Moore del.

Bur (*Solanum rostratum*), and was not thought of as of any economic importance. The name "decemlineata" refers to the ten black stripes on the elytra. The years passed, and the far west was colonized by the farmers, who planted potatoes, belonging to the same botanical group as the buffalo bur. The beetles soon sensed the abundant supply of food, and spread from field to field, even to the Atlantic seaboard. They proved to be one of the major pests, to be destroyed or kept in check if one expected to raise potatoes. Arsenical poisons were used in vast amounts, and many a lad found uncongenial occupation in picking potato beetles. Europe was seriously alarmed. Many European pests had crossed to America, inflicting enormous damage. What if America should reciprocate, and the potato beetle become established in the Old World? Strenuous efforts were made to avoid such a calamity, and the public press issued numerous warnings. In England, where it is customary to sing in the streets, the popular song of the day dealt with this topic, with the refrain:

"You'd better mind your bread and cheese, and everything you've got
For the collar-larder beetle's come, to swallow the jolly lot!"

Which, if it lacked refinement, was good advertising for economic entomology.

In Colorado, *Leptinotarsa decemlineata* is usually uncommon, or at least not abundant. It is migratory, and at the end of May and beginning of June, 1910, it appeared in great numbers in Boulder, flying. It attacked the tomato plants in my garden, but did not continue during succeeding years. At the time of the World War, this beetle succeeded in getting established in France, and there is reason to think that it may spread widely over Europe.

Rather closely related to the potato beetle are certain other members of the family Chrysomelidae. *Chrysomela* means golden apple in Greek, in reference to the rounded form and golden color of some of the species. A good example is *Chrysomela auripennis*,

another of Say's discoveries, which we have found on the University campus at Boulder. It is oval, with the elytra or wing-covers golden green, but the head, thorax and legs rich purple. Still another of Say's species, found at Boulder, is *C. flavomarginata;* dark, almost black, with the outer margin of the elytra broadly orange tending to red. The sunflower beetle, *Zygogramma exclamationis*, looks like a small potato beetle, but the thorax is without black spots, and the outer stripe on the elytra is broken, looking like an exclamation-mark. This insect is common on sunflowers in Boulder, and sometimes quite destructive. A much smaller and narrower beetle, with cream-colored spots on the steel blue elytra, and red thorax, is destructive to asparagus. It is called *Crioceris asparagi*, and was introduced from Europe. Its arrival in Colorado is much to be regretted, as formerly we could grow asparagus free from serious pests.

At first sight, it is often possible to confuse the Lady-birds or Lady-beetles (Coccinellidae) with the Chrysomelidae. They have the tarsi or feet apparently three-jointed, while in the Chrysomelidae there are apparently four joints. While the Chrysomelidae are plant feeders, the Coccinellidae devour plant lice and scale insects, with few exceptions. The one great exception in our region is the Bean Lady-beetle, *Epilachna corrupta*, which is extremely destructive to beans along the eastern foothills of Colorado. It is broadly rounded, clay yellow, with black spots. It is supposed to have come from Mexico, but has long been known in New Mexico and Colorado. When Chittenden wrote Bulletin 843 of the U. S. Department of Agriculture, on the Bean Lady-bird, in 1920, he indicated its occurrence in Colorado, New Mexico, Arizona and western Texas. Suddenly it gained a foothold in the Southern States, and Bulletin 221 of the Alabama Experiment Station shows a wide distribution in Alabama, Georgia, North and South Carolina, Tennessee, Kentucky, and up into Ohio. The beetles spread by flying, and no one knows how much territory they will eventually cover. Wherever they go they are a major pest, comparable to the potato beetle. Formerly, their eastward distribution was undoubtedly limited by the unfavorable conditions of the plains; but having crossed this boundary, presumably in some train, they find few obstacles to rapid spread in the territory they have reached. The common

lady beetles which prey on other insects are mostly red with black spots, and belong to a number of different species. One species, found on the University campus, has the elytra black, each with a large red spot. It is called *Chilocorus bivulnerus*, the specific name meaning twice wounded, on account of the two red spots. This is one of the important enemies of scale insects on trees.

Thoreau, in "Walden," refers to the beautiful bug which came out of the furniture. This was a *Buprestis*, of the family Buprestidae, generally known by the peculiar form, wedge-shaped posteriorly. Such a species is *Buprestis aurulenta*, which came from a board walk at Las Vegas, New Mexico, the larva having occupied a tunnel in the wood. It is about three quarters of an inch long, emerald green, the elytra with rosy margins. Col. Casey described a supposed new species, *B. aemula*, from Boulder County, Colorado, but it is considered to represent only a variation of this *B. aurulenta*.

Another very beautiful species found in our region is *B. langi*, bright green with two yellow marks on each elytron. It was originally described from Sitka, Alaska, but S. A. Rohwer found it on willow at Boulder. Col. Casey thought the Boulder County form should be separated, and called it *B. graminea*, the name meaning grass-green. A much smaller but no less beautiful member of the family is *Chrysophana placida*, which was found near Allen's Park in July. It is about three-eights of an inch long, bright green, with a broad rosy-red band down the middle of each elytron. The Elateridae, or click-beetles, somewhat resemble the Buprestidae, but are more slender, more obtuse posteriorly, and dull colored in nearly all cases, black to reddish. The posterior corners of the thorax, as seen from above, are more or less elongated and pointed. The larvae live in decaying wood or in the earth, and are called wire-worms. We have many species in Colorado, but they attract little attention. Perhaps the most interesting is *Anthracopteryx hiemalis*, peculiar to Colorado, and found only during the early months of the year. It seems to be allied to Australian and Patagonian genera.

The Scarabaeidae are lamellicorn beetles; that is the club or end part of the antennae is composed of a number of laterally elongated joints, closely pressed together, but separable. This is

the group containing the common June-bug, and the May-beetle or cockchafer of Europe, as well as the sacred Scarabaeus of the ancient Egyptians. The fat curved larvae may often be found in the ground, injuring the roots of plants. The Colorado species are quite numerous, some of them large and conspicuous. Thus the common *Euphoria inda*, found on thistles, has the elytra warm reddish, speckled with black. According to Casey, the true or typical *inda* of Linnaeus comes only as far west as Nebraska, and he proposed to separate our insect under the name *E. rufobrunnea*. The large *Polyphylla decemlineata* of Say, which has been taken in Boulder (Elizabeth Benson), has seven cream colored stripes down the back. Between the stripes, the surface appears greenish, but this is an optical illusion, due to minute yellow scales on a black ground. I have found the larva of this beetle at White Rocks near Boulder. A curious rather narrow black scarabaeid, *Cremastocheilus knochi*, is found only in the nests of ants, being one of the insects called myrmecophiles, or ant-lovers.

The Cerambycidae or longicorn beetles, are usually known by the very long antennae. The larvae are most frequently found boring in trees, but some infest herbaceous plants, and there is a curious genus on cacti. We have a very large species, not uncommon, which is over two inches long, the elytra with pale marbling on a dark ground, and the thorax spined at the sides. This is *Ergates spiculatus neomexicanus* of Casey. Almost simultaneously with Casey's publication, (1890) I named this beetle *marmoratus*, and in discussing the matter later, Col. Casey was not able to say which was published first. However, there seems to be good evidence that the name given by Casey has priority. *Cyllene robiniae* is the locust borer, only recently introduced into Colorado from the eastern states. The larvae are very destructive to the locust tree (*Robinia*), as may be seen on the University of Colorado campus. The beetle is about three-quarters of an inch long, with transverse curved and angular canary-yellow bands on a black ground. Bright red longicorns found on milkweed belong to the genus *Tetraopes*. Dark colored species with finely crinkled elytra and excessively long antennae are *Monohammus*. Rather small dark purple forms belong to *Callidium*. Altogether the longicorns form a large and very

attractive group, great favorites with collectors. They were probably even more abundant in former times than now, no less than 28 species having been found fossil at Florissant.

The weevils or Curculionidae are excessively numerous, and often difficult to distinguish. The head is prolonged into a snout or beak, at the end of which is the mouth. One of our most familiar kinds is the deep red *Rhynchites bicolor wickhami*, which is very injurious to rose bushes, attacking the buds and causing them to wither. Related to the weevils, but with very short and broad rostrum are the Scolytidae or bark beetles, which do great damage to forest trees. On stripping off the bark of a dead tree their radiating galleries may often be seen. There is a small species which lives in seeds of *Pinus flexilis* at Ward.

There is a very important series of beetles known as Heteromera, distinguished by having the hind tarsi with fewer joints than those of the other legs. There are probably nearly 20,000 species known in the world, and of these a considerable number occur in Colorado. Some of the families include few species, or the species are small and inconspicuous, but others come to the notice of any one who pays the least attention to insects. The Mordellidae, obtuse in front and sharply pointed behind, are small beetles common on flowers. They are agile, and at the least disturbance fall to the ground. The Meloidae or blister beetles, and the Tenebrionidae or darkling beetles are the most important families. Meloidae are soft bodied beetles, the thorax narrowed behind the head, giving the appearance of a neck. The adults are often destructive to vegetation, while the larvae are parasitic in nests of wild bees, or in some instances feed on the eggs of grasshoppers. Our most conspicuous species is the green *Lytta nuttalli*, three-quarters of an inch long or more. It occurs on herbaceous plants in the mountains, and was named by Say after Nuttall, the distinguished botanist and all-round naturalist who explored the west in the early days. Species of *Meloe* are large and fat, black, with short wing covers and no wings. They exude an oily fluid from the joints when disturbed, and must on no account be collected in a bottle with other insects, or they will ruin the whole lot. A still more singular form is the *Leonidia neomexicana*, which is completely apterous and larva-like, and lives in the nests of the tunnelling *Anthophora* bee. It is found

in Colorado, Kansas and New Mexico. *Tricraniodes stansburyi*, found in Boulder in May (Maxy Pope) is of moderate size, black, with very bright red elytra. The claws are very peculiar, having a long bristle-like structure from near the base, while the main part of the claw has fine comb-like teeth.

The Tenebrionidae are nearly all black, slow moving, some quite large. The common and characteristic genus of the dry regions of the west is *Eleodes*. These beetles live upon the ground, and when disturbed elevate the posterior end and emit an extremely disagreeable odor. They are very hard to kill in the cyanide bottle, seeming to be resistant to noxious gases. But one of my students, Mr. Clement Sutton, discovered that with an *Eleodes* he could make a very efficient killing-bottle for other insects. As they have no wings, and can only travel on foot, these beetles tend to form isolated colonies with distinctive characters, and an intensive study of them, combining field and laboratory work, would be of great interest and value. The student who should undertake this would find his work made comparably easy by the admirable monograph of the group by Dr. F. E. Blaisdell, published in 1909 as Bulletin 63 of the U. S. National Museum.

The Cleridae or checkered beetles do not usually attract much attention, but two or three Colorado species are remarkable for their beauty. The larvae destroy other insect larvae. On flowers one may often find *Trichodes ornatus* of Say, usually about three-eights of an inch long, parallel-sided, with yellow markings on a steel blue ground. The thorax is usually steel blue or greenish blue, but a western form (variety *douglasianus*), which I have from Lake Tahoe, California, has it yellowish green. Even in Boulder, Colorado, specimens occur with green thorax. There is also a smaller species, *Trichodes nuttalli* of Kirby, not uncommon at Boulder, which is steel blue marked with blood red. It has been taken on flowers of mariposa lily, *Calochortus gunnisoni*, by Mrs. Cockerell. An equally beautiful species, with red thorax, and the middle of the elytra broadly bright red, is *Enoclerus coccineus*. It was named as recently as 1906.

The Cantharidae or Telephoridae are softened, flattened, mostly parallel-sided beetles, often found on flowers. Our common genus is *Chauliognathus*; the name has rather a hibernian

sound. The beetles are black and yellow; *C. basalis* has a large black patch at the base of the elytra, including the scutellum, while *C. pennsylvanicus* has the scutellum black, but the basal part of the elytra entirely clay-yellow. The closely related Lampyridae include the lightning-bugs so common in the eastern states, but not often seen in Colorado. On May 26, 1889, I found *Pyractomena borealis* at Westcliffe in Custer County, and noted its bright light. I found that I could intensify the light by pressing the anterior half of the beetle between the finger and thumb. Many authors regard the Lampyridae as only a subfamily of Cantharidae, distinguished by having the antennae closer together.

Of the Erotylidae, which are especially abundant in the tropics, we have one common and conspicuous form, *Cypherotylus aspersus*. It is elongate-oval, nearly three-quarters of an inch long, the head and thorax black, the elytra pale greenish with many small black spots, which are depressed in the middle. I found it breeding in an old pine stump near Allen's Park. One of the most remarkable of all beetles is the *Platypsyllus castoris*, forming a family Platypsyllidae. The name means flat flea, and it is parasitic on beavers. It was found in 1868 on an American beaver in the Zoological Garden at Rotterdam, but has since been found on wild beavers both in Europe and America. The beavers of the two continents have become sufficiently modified to be considered distinct species, but their parasite has been more conservative, remaining apparently unchanged. *Platypsyllus* was first found in Colorado by Ralph Hubbard, on beavers obtained by Alfred Wheeler in South Boulder Creek.

The Histeridae are usually broad, thick set, shiny beetles, the elytra not reaching the end of the abdomen. They are found in dung and under dead animals. The genus *Hololepta* is excessively flattened, adapted for living under bark. The genus was added to the Colorado fauna when a specimen of *H. fossularis* Say was found by Georgia Johnson under the bark of a dead cottonwood tree in Boulder, May, 1922. Another peculiar genus is *Hetaerius*, consisting of small species found in nests of ants. The very smallest species (1.25 to 1.5 mm. long) was discovered at Boulder and named *H. minimus* by Fall.

The Silphidae include carrion beetles and burying beetles.

The latter, often found under dead animals, form the genus *Necrophorus*, recognisable by the rather large size, and the black and reddish-orange markings of the short truncated elytra. *N. tomentosus* has the thorax above with much yellowish hair, but in *N. guttula* and the closely related *N. hecate*, it is bare. The species of *Silpha* or carrion beetles are broad and flattened. Our commonest species is *S. lapponica*, first known from Lapland. The broad thorax has thin yellowish hair; the elytra are dull black, with raised lines or keels, and rows of tubercles between them.

Staphylinidae are usually known by the elongate form and very short elytra, so that at first sight they appear not to be beetles. In spite of the short elytra, the wings are well developed, and the insects may often be seen in flight. In England there is a minute species which habitually flies at dusk, at about the level of the human head and causes annoyance by getting into people's eyes. Most of the species are small, but the common *Creophilus villosus* is considerably over half an inch long, and is also distinguished by the abundant pale yellow hair on the second and third abdominal segments. Our prettiest species belong to *Paederus*, small and slender, head and end of abdomen black, thorax and rest of abdomen bright ferruginous red, elytra steel blue. The very small Staphylinidae are extremely numerous and difficult to classify.

Paussidae are small beetles, often with extraordinary antennae, which occur in ant's nests. They are entirely absent from the present fauna of the United States, but a genus (*Paussopsis*), with two species, is found fossil in the Miocene shales at Florissant.

The water beetles belong to several families, the Dytiscidae and Hydrophilidae being most common. In the former, the slender antennae are eleven jointed, without hair; in the latter the shorter antennae are six to nine jointed, the end joints forming a hairy club. There are many other differences, showing that the aquatic habit and similarity of external form has been acquired quite independently in the two groups. In dealing with the larger Hydrophilidae it is necessary to avoid mistaking the long slender maxillary palpi for antennae.

The Carabidae or ground beetles are extremely abundant

almost everywhere. These are the active beetles commonly found under rocks, the elytra frequently shiny and with fine striae or grooves. Many are black, but some are green, others blue or purple, still others red. The species of *Chlaenius* are of fair size, green, often with bright red legs; the elytra have a dull surface. In *Brachynus* the narrow head and thorax are clear red, while the elytra are purple. Species of *Lebia* are small and prettily colored; green (*L. viridis*), or with dark purple elytra, red thorax and black head (*L. atriceps*), or with dark blue head, red thorax, and elytra mainly orange at the base, and greenish blue beyond (*L. divisa*). The last is usually considered a rare species, but it is not uncommon at Boulder. At Salina and in Wet Mountain Valley I have taken another rare species, *L. vivida* of Bates.

The tiger beetles or Cicindelidae, very active beetles with long legs and prominent eyes, are numerous in Colorado. They are found in sandy places, and move so quickly that they are sometimes taken for flies. The elytra are of various colors, usually with distinct light markings. The voracious larvae live in burrows in the ground. *Cicindela formosa* of Say, which I found at White Rocks, near Boulder, is rich, deep, rosy red above, the elytra with dull surface, and with a white outer margin, from which arise inward extensions of the same color, the middle one bent and with rounded end. *Cicindela purpurea*, a common species, is obscure purplish, with the outer margins of the elytra brilliant peacock blue and green. The light markings are greatly reduced. It varies however, and in one form (var. *audubonii*) the purple, blue and green are replaced with black. *C. punctulata* var. *boulderensis* was described by Casey from Boulder County; it is said to be more elongate than usual, convex, rather dull, dark coppery brown, the sides of the abdomen densely pubescent. *C. limbalis* var. *eldorensis* of Casey came from Eldora, and was said to be smaller and more slender than the typical form.

It is a singular thing, that although tiger beetles are now so abundant in Colorado, not a single species has ever been found fossil at Florissant or any where in America.

DIPTERA (Flies)

The Diptera, or two-winged flies, are so numerous that an account of the Colorado species would fill a large volume. Some

are noteworthy as carriers of the germs of disease, some annoy us by their bites, some attack our crops and others our domestic animals, but others confer a benefit by devouring injurious insects. Although there are only two fuctional wings, the hind pair exists in rudimentary form, being modified into small stalks with a knob at the end, called halteres.

Diptera are very interesting from the standpoint of evolution. A group of great antiquity, they have reached in certain forms, such as the house fly, a very high degree of specialization. At the same time, many of the more primitive types, such as the crane-flies, have survived in great numbers, and we have a series showing various degrees of modification. In the present account it is possible to discuss only some of the more interesting families.

Tipulidae or Crane-flies

These long-legged insects, called daddy-long-legs in England, are extremely abundant, some of large size, others quite minute. Dr. C. P. Alexander, in his work on the Crane-flies of New York, published (1919, 1920) by Cornell University, has given an admirable account of the family, describing both structure and habits. I have catalogued over 50 species from Colorado, but many more exist. The fossil forms are also very numerous, and at Florissant we find species of *Tipula* in the Miocene shales, still showing the markings of the wings and abdomen. The larvae of some species of *Tipula* are very destructive to grass and cereals.

The Dixidae, an interesting family of small flies, was added to our list when Mr. Scott Gale found the new species *Dixa universitatis* Cockerell on the University of Colorado campus, September 27, 1926.

Chironomidae

A family of small gnats, often taken for mosquitoes. The typical Chironomidae, often found on windows, are quite inoffensive. Some of them have red worm-like larvae, called bloodworms, living in stagnant water. The group Ceratopogoninae, sometimes regarded as a separate family, includes the excessively minute punkies, which will come through an ordinary mosquito-screen, and bite viciously. Troublesome species in Colorado are

Leptoconops torrens of Townsend, which we have found at Lake George, and different kinds of *Culicoides*, as *C. sanguisuga* and *C. cockerelli* of Coquillett. The latter was first recorded as the wound-gnat, in the Second Report of the Colorado Biological Association (Jan. 1889). It was found in Wet Mountain Valley, attracted by wounds on a horse. *C. sanguisuga* extends northwestward, and is said by Essig to be "a specially bloodthirsty species in British Columbia and Oregon".

The Psychodidae, or moth-like flies, may often be found on windows. The wide-spread *Psychoda phalaenoides* of Linnaeus (*cinerea* of Banks) is found in Colorado.

The fungus-gnats or Mycetophilidae are abundant, but have been little studied in Colorado. My list includes only eight species. The Bibionidae, so-called March-flies, are few in species, but often very numerous in individuals. They are of fair size, with quite short antennae. The Simuliidae, called buffalo-gnats or black flies, breed in rapid streams; and the flies, which are small with a convex or humped thorax, may often be found in the mountains and foothills. The females suck blood, and are frequently annoying, I have six species recorded from Colorado. The Blepharoceridae, also breeding in running streams, and having very peculiar larvae, are called net-winged midges. They really look more like crane-flies, and are remarkable for the net work of fine lines in addition to the regular venation. We have two species; one of them, *Bibiocephala elegantula* of von Roeder, was found by Middle St. Vrain Creek, above Peaceful Valley, feeding on a May-fly.

Culicidae (*Mosquitoes*)

The mosquitoes of Colorado received special attention during the war, on account of the danger from malaria. The parasite causing this disease is carried by mosquitoes of the genus *Anopheles*, and wherever these are present the disease is liable to appear. At the present time, we know *Anopheles quadrimaculatus* of Say from Delta County, but among numerous mosquitoes collected in other parts of Colorado, no *Anopheles* has been found. It seems that the carrier of malaria is absent, or if not absent very rare, in an area including eastern Colorado, Wyoming, Nebraska, the Dakotas, and some adjacent regions. With these

exceptions, it occurs practically all over the United States. A practical result of this condition is that persons from the tropics or other malarious regions may come here to recuperate, and if they carry germs of malaria in their bodies, they will not be a menace to the rest of the population, as they would be in the presence of *Anopheles*. Indeed, strange as the idea may at first appear, Colorado would be a very good place for the location of a School of Tropical Medicine, where medical men from the tropics might come and work up their materials while at the same time improving their health.

A list of the mosquitoes of Colorado was given by the writer in Journal of Economic Entomology, 1918. More recently (Insecutor Inscitiae Menstruus, 1924) Dr. H. G. Dyar has published a new list, with a number of additions. Dr. Dyar made collections at Grand Lake in the early spring of 1923, and says, "I was fortunate enough to arrive before the Public Health Service had completed its extermination work. These mountain mosquitoes are so easy to destroy that it seems almost like taking an undue advantage of nature. Certainly the able and sharp-eyed man who had been employed to spread oil on the pools left little enough for a late collector". The combined lists give about 20 species of *Aedes* (which are the common mosquitoes), four of *Theobaldia*, one of *Culex*, and one of *Anopheles*. The high mountain species represent what Dyar calls the Canadian fauna, extending north through Wyoming and Montana to Canada.

Cecidomyiidae or Gall-gnats

These minute and delicate flies, with many-jointed antennae, are of importance because many of the species have larvae which live in the tissues of plants, producing galls. These larvae are usually of an orange color, and may be found on breaking open a gall. Some of the principal Cecidomyiid galls of Colorado are the following:

(1) Bud galls on *Pinus scopulorum*, due to *Contarinia coloradensis* Felt.

(2) Kidney shaped enlargements at base of needles of *Pinus edulis*, due to *Thecodiplosis cockerelli* Felt.

(3) Reddish conical gall on *Juniperus utahensis* at McCoy. *Oligotrophus betheli* Felt.

(4) Stout fusiform gall on willow. *Phytophaga rigidae* Osten Sacken. There is a rather similar gall due to a saw fly.

(5) Cabbage-like gall common on willow. *Rhabdophaga brassicoides* Walsh.

(6) Large cone-like terminal gall on willow. *Rhabdophaga strobiloides* Walsh.

(7) Potato-like gall on willow. *Rhabdophaga batatas* Walsh.

(8) Slightly enlarged branches of willow. *Phytophaga perocculta* Cockerell. (The common galls on cottonwoods are due to Aphides).

(9) Rounded fuzzy galls on *Atriplex canescens*, as far north as White Rocks in Boulder County. *Asphondylia neomexicana* Cockerell.

(10) Galls in stems of *Allionia*, found by E. Bethel at Boulder. *Lasioptera allioniae* Felt.

(11) Flower-gall, with thickened, enlarged sepals, on *Stanleya glauca*. *Perrisia stanleyae* Cockerell.

(12) Swollen fruit of *Opuntia*, the prickly-pear cactus. *Asphondylia betheli* Cockerell.

(13) Flower-bud gall on *Gutierrezia*. *Rhopalomyia gutierreziae* Cockerell.

(14) Stem-gall on *Chrysothamnus*. *Rhopalomyia bigeloviae* Cockerell. A different gall on *Chrysothamnus* is caused by *Asteromyia chrysothamni* Felt. It was found near Boulder by Bethel.

(15) Round woolly galls on *Artemisia*. *Rhopalomyia alticola* Cockerell (Kieffer refers this to *Miospatha*).

(16) White pubescent gall on *Artemisia gnaphalodes*. *Rhopalomyia gnaphalodis* Felt.

(17) Small fusiform galls on *Artemisia frigida*. *Rhopalomyia betheliana* Cockerell.

(18) Galls in deformed flower heads of *Artemisia* at Colorado Springs. *Rhopalomyia coloradella* Cockerell.

(19) Small galls densely covered with white hair, on *Aster crassulinus*. *Rhopalomyia crassulina* Cockerell.

Rhopalomyia coloradella *Ckll.* Midge gall on sage (Artemisia), Colorado Springs. Evelyn Moore del.

Rhopalomyia cockerelli Felt was found on a window at Boulder; it probably comes from a gall in *Senecio* or *Aster*. *Dasyneura cercocarpi* Felt forms a gall on *Cercocarpus* at Golden,

and *Asphondylia shepherdiae* Felt on *Lepargyraea* at Lake Eldora. Many new Cecidomyiid galls doubtless await discovery.

The Stratiomyiidae, or Soldier-flies, have about 24 known Colorado species, but they do not attract much attention. They may usually be recognized by the small cell or enclosed space near the middle of the wing. Frequently the abdomen is broad, and prettily colored or ornamented. The Tabanidae, or Horse-flies and Deer-flies, are large insects, too well known to all ranchmen. Their eyes are beautifully marked with colored bands, which fade after death. The larvae are fat worm-like creatures living in wet places. We have 23 recorded Colorado species, of which 13 belong to *Tabanus*, which contains the ordinary large horse-flies. The smaller and more elegant species of *Chrysops* are often very troublesome; thus I was persistently attacked by *Chrysops fulvaster* of Osten Sacken when collecting fossils in the Roan Mountains.

The Rhagionidae (Leptidae) are rarely noticed, except the genus *Symphoromyia*, which persistently sucks blood. Two species, *S. atripes* Bigot and *S. hirta* Johnson, are particularly noticeable in this respect. When gorging themselves on one's hands or face they seem to lose all fear, and may be readily picked off and destroyed.

The Nemestrinidae, with very extraordinary venation, were apparently common in Tertiary times, as shown by the fossils at

Nemestrinid Fly

Hirmoneura occultator. Found by S. A. Rohwer in the Miocene shales at Florissant. Drawn by Ruth Isensee

Florissant. Today they are excessively rare in Colorado, and I have never captured a specimen. Mr. L. O. Jackson had the good fortune to find *Rhynchocephalus sackeni* of Williston visiting flowers of *Eriogonum umbellatum* at Boulder, June 20, 1922.

The Asilidae, or Robber-flies, are usually large with long tapering bodies and long legs. They prey on other insects, which they may often be seen carrying. I find 27 species recorded from Colorado. One of these, *Dasyllis fernaldi* of Back, curiously resembles a bumble-bee.

The Bombyliidae, so-called Bee-flies, are also numerous. In the Miocene shales at Florissant are many genera and species, but these represent a fauna almost wholly distinct in character from that now living in Colorado. For some reason not explained, the Miocene genera disappeared, and were replaced by unrelated genera of bee-flies which now occupy the country. The fuzzy *Bombylius major* of Linnaeus is circumpolar, being found equally in Britain and Colorado. *Phthiria sulphurea* of Loew is a small yellow species which may be found on yellow flowers, such as sunflower or *Grindelia*. It is sometimes caught by the predatory yellow bug *Phymata fasciata*. The Therevidae, or Stiletto-flies, are not often noticed. *Thereva cockerelli* Cole is a silvery-white fly, about nine mm. long, discovered in Peaceful Valley, Boulder County, but ranging north to Manitoba and Michigan. The Dolichopodidae are small long-legged usually bright metallic-green flies, often seen running on foliage. The legs of the males are often curiously formed or ornamented. Although these flies are plentiful today, we cannot find any of them fossil in the shales.

Syrphidae

The Flower-flies, Hover-flies, Drone-flies, etc., are conspicuous on flowers everywhere, and many of the species are beneficial to man, the larvae feeding on plant-lice. There are however some very curious species, with thick bodies, the slug-like larvae of which occur in ants' nests. These belong to the genus *Microdon*, and the larvae are so much like molluscs that they have on more than one occasion been actually described as such. A very fine new species of this genus, *Microdon coloradensis* Cockerell and Andrews, was bred from the larva in Boulder. A second species, obtained at the same time, was considered a variety of *M. cothur-*

natus Bigot. It has since been rather ambiguously set forth by Mr. C. R. Jones (Contr. Knowl. Syrphidae Colo., 1922) as *M. tristis cockerelli*. The species of *Cheilosia*, of which we have seven, live under the bark of coniferous trees, often causing damage. The larvae of *Volucella* are scavengers in the nests of bees, and the adults are often very similar to the bees in appearance. Very similar to *Volucella* in appearance, and also liable to be taken for bees, are the species of *Eristalis*, the larvae of which are called rat-tailed maggots. They live in water or wet mud, and have a long tail-like respiratory tube. The Onion-fly, *Eumerus strigatus* of Fallen, is a native of Europe, recently introduced into America with bulbs. When it appeared some years ago at Fort Collins, it was not unnaturally taken for a native insect, and was described as *Microxylota robii* Jones. For a full account of the Colorado Syrphidae see C. R. Jones in Annals Entom. Soc. America, 1917, and Bulletin 269, Colorado Agricultural Experiment Station (1922).

The Oestridae, or Bot-flies and Gad-flies, include the stomach bot of the horse (*Gastrophilus intestinalis*), which was reported from Colorado by Osten Sacken as early as 1874; the Ox-bot or Warble fly (*Hypoderma lineata*); and the very large stout flies of the genus *Cuterebra* and *Bogeria*, the larvae of which infest rabbits, rats and mice. The Warble fly lays its eggs on the hair of cattle, and the larvae locate under the skin, causing swellings known as warbles. They eventually escape through holes and pupate in the ground. The loss from these insects, especially to the leather industry, is so enormous that plans have been discussed for concerted action all over the country, in the hope of exterminating the pest.

In the Green River Shales of Western Colorado fossil bot-fly larvae (*Lithohypoderma ascarides* Scudder) are extremely numerous, but their history and origin puzzle all investigators. Is it possible that the waters were saline, and the heavily infested animals (of what species we have no knowledge) found that they would cause the larvae to leave the warbles?

The family Tachinidae is a bewildering complex of closely related genera and species of bristly flies, parasitic on various insects in the larva state. The group is thus extremely beneficial to man, especially as keeping down the multitudes of caterpillars

which attack our crops. Not only are there many forms differing greatly in appearance, but in certain genera we have series of very closely allied species, requiring anatomical studies for proper discrimination. Thus in the genus *Peleteria* we had listed three supposedly well known species. Mr. C. H. Curran, making a critical revision, found that none of these occured in Colorado, but instead we had no less than thirteen new species. One of these, *P. campestris* Curran, has been taken on the campus of the University of Colorado (Ada Kneale). A previously known species, *P. iterans* Walker, was taken at Ward (W. P. Cockerell). These were determined by Mr. Curran. A pretty species, easily recognized by the abdomen having the basal half or more pale yellow, the apical portion black, is *Xanthopalpus bicolor* Williston. It occurs on flowers of *Rudbeckia laciniata* in Peaceful Valley, and was found in the Hudsonian Zone on Long's Peak trail.

The related Sarcophagidae have a peculiarly marked abdomen, with a sort of checker-board effect, and the tip is often red. We have sixteen species belonging to the genus *Sarcophaga*. *S. eleodis* Aldrich is parasitic on the slow moving evil smelling beetles of the genus *Eleodes*. Several species are parasitic on grasshoppers.

The limits of the family Muscidae are subject to dispute, but as generally understood we may include the following common flies:

Pollenia rudis Fabricius, which is parasitic in the larva state on earthworms. The flies collect in houses, and sometimes become so abundant as to cause great inconvenience. (See Nature, Feb. 9, 1924, p. 193.) It is known by the loose yellow pile on thorax.

Calliphora erythrocephala Meigen, the common bluebottle fly.

Lucilia caesar Linnaeus, the greenbottle fly, smaller than the last. There are other related forms, such as *Protophormia terrae-novae* Desvoidy, which occurs on the University of Colorado campus (Phyllis Burk) and up to timber line on the Long's Peak trail. It is a much darker insect than the greenbottle. *Cryptolucilia caesarion* Meigen is a common green fly very like the greenbottle, but metallic between the eyes, and with a prominent bristle on the inner surface of each middle tibia.

Musca domestica Linnaeus, the common house fly, much re-

duced in numbers since the automobile came in, as it breeds principally in horse manure.

Stomoxys calcitrans Linnaeus, very like a house fly, but with a proboscis adapted for sucking blood. It is often called the Stable Fly, and has been suspected of carrying the organisms of disease.

Haematobia serrata Desvoidy, the Horn Fly, smaller than the house fly, and found on cattle, causing them annoyance by their bites. It has been noticed at the lower end of Boulder Canyon.

In the shales at Florissant, we find no Muscidae, Sarcophagidae, or Tachinidae, but instead several fossil species of Glossinidae, the tsetse flies, now existing in Africa.

There are numerous families of mostly small flies related to the Muscidae, but we cannot describe them here. *Eurosta bigeloviae* Cockerell, in the family Trypetidae, is a fly with prettily marked wings, which breeds in rounded white galls on stems of *Chrysothamnus*.

Drosophila melanogaster Meigen, of the Drosophilidae, is the little red-eyed fruit fly which in the hands of Professor T. H. Morgan and his associates has revolutionized the science of heredity, developing the Mendelian theory in ways previously unimagined. It may occasionally be found on windows in Boulder and elsewhere. The Wheat-stem Maggot, *Meromyza americana* Fitch, of the Chloropidae, is injurious to wheat.

The curious parasitic fly *Trichobius corynorhini* Cockerell (Family Hippoboscidae) is found on the Big-eared Bat (*Corynorhinus*). It was first found in the Great Sphinx Mine, Boulder County.

HYMENOPTERA

The great group of ants, bees, wasps, sawflies, etc., richly represented in Colorado. Opinions differ as to the number of families to be recognized, but in recent years the tendency has been to divide them more and more. In Comstock's Introduction to Entomology (1924) some of the currently recognized families of bees and wasps are united, but the result seems to me to be confusing. The arrangement given by Essig, in his

Insects of Western North America, is I think much to be preferred. There are so many kinds of Hymenoptera that even a brief treatment of the Colorado species would fill a large volume. All we can do here is to call attention to a few of the most interesting.

Sawflies and Horntails (Tenthredinoidea)

The Horntails (Siricidae) are large parallel-sided insects, the females with a long tail-like ovipositor. They come from larvae boring in the wood of trees. The group is a very ancient one, the oldest known Hymenoptera (from the Mesozoic) being rather closely related to the living horntails. There is a very large ichneumon-fly (*Megarhyssa*) which is parasitic on the larvae of horntails, and inserts its extremely long ovipositor into the trunks of trees to reach its prey, and there deposit its eggs. *Urocerus flavicornis* Fabricius is a large horntail of the mountains and north. The female is not much less than an inch and a half long, counting the ovipositor. It is black, with two orange bands on the abdomen. It was long ago taken in Boulder Canyon by Putnam, and in Wet Mountain Valley. It is reported from Labrador, and Mrs. Cockerell took it at White Horse in the Yukon. It breeds in coniferous trees. Sawflies (Tenthredinidae) are usually of moderate size, some very small. They have no constricted waist, such as is seen in wasps and bees. The larvae of most species feed on foliage, and are caterpillar-like. One form, introduced from Europe, is the Pear-slug (*Eriocampoides limacina* Retzius). The slug-like larvae eat the surface from the leaves of pear, cherry and hawthorn, and are very destructive. I have found them on the wild hawthorn at Boulder, a matter of some consequence, as they can survive there, even though destroyed in the gardens. Another imported pest is the Currant-worm (*Pteronidea ribesii* Scopoli), the larvae injurious to currants and gooseberries. In 1906 I found a supposed new species in Boulder, and named it *P. arapahonum*, but it now turns out it was only a slight color variation of the imported *P. ribesii*. Still another pest is the small black *Caliroa aethiops* Fabricius, found on cultivated roses. Dogwood (*Cornus*) bushes in the grounds of the Court House at Boulder were severely injured by the larvae of *Harpiphorus varians* Norton.

Ichneumon-flies (Ichneumonoidea)

These include several families, and a bewildering complex of species. The genus *Amblyteles* is extremely rich in species. Several years ago, I collected many of these in Boulder County, and securing the literature and a good series of named species from the Eastern States, thought I would identify what I had. To my astonishment, I could match hardly any of them, and on submitting eleven perplexing forms to Mr. R. A. Cushman, of the U. S. National Museum, was informed that they were all apparently undescribed, though possibly some were variants of described species. The specimens are now in Washington, and it is presumed that they will later be described by Mr. Cushman. We have about nine Colorado species definitely identified, and others were long ago recorded by Cresson. The latest addition is *Amblyteles cincticornis* Cresson, Boulder, October 11 (Chas. Wagner). *A. suturalis* Cresson is a common red species often found under rocks. *Orthopelma* is parasitic in galls; in 1927, at the end of March, *O. rosaecola* Ashmead was reared from a gall of *Rhodites variabilis* Bassett, found on wild rose at Boulder, by Chas. Wagner. This species was described by Ashmead as doubtfully from Colorado.

Orthopelma rosaecola. Wings, enlarged.

Gall-flies (Cynipidae)

These form galls on roses and oaks, and occasionally on other plants. The oak galls are of various kinds, but some are large and round, and are called oak-apples. The species of *Rhodites* infest roses. The cultivated sweet briar is the host of the introduced *R. rosae* Linnaeus. The galls resemble large tufts of hair, and when fresh are quite pretty, being suffused with red. When old they turn dull brown, and disfigure the then leafless bushes. The native *Rhodites*, living on wild roses, have quite different galls. That of *R. tuberculator* Cockerell is large and irregular, something like a potato. That of *R. fusiformans* Ashmead is elongate, fusiform, with a russet surface. That of *R. rosaefolii* Cockerell is a pustule-like swelling in a leaflet. That of *R. bicolor*

Galls of Rhodites rosaefolii *Ckll.* on rose. Evelyn Moore del.

Harris is spherical, spiny, not very large, but there are usually several together. *R. variabilis* Bassett produces rather small smooth rounded galls, more or less in a cluster. It is interesting to gather these galls, and those from the oaks, very early in the year, and see the insects emerge in spring and early summer. The observer will obtain not only the true gall insects, but many parasitic species, some of them metallic green. These green parasites belong to the Callimomidae of the Chalcidoidea. The females have long ovipositors. An exceptional member of the Cynipidae is *Aylax pisum* Walsh, which forms pea-like stem galls on *Lygodesmia*, one of the Compositae. It may be found in the vicinity of Denver.

Ants (Formicoidea)

The Colorado ants are placed in four families, but two of these are sparingly represented. The pedicel or basal part of the abdomen has two nodes or specialized segments in the Myrmicidae, but in the other families there is only one such segment. Only one of the latter (Poneridae) has the sting developed; the Formicidae and Dolichoderidae are incapable of stinging. Our Poneridae are very small, slow moving ants, and their nests are not at all populous. The modified segment at the base of the abdomen is obtuse or truncate above, seen in side view. Wheeler took one specimen of the yellowish-red *Ponera inexorata* Wheeler near Colorado Springs, and *P. opaciceps* Mayr is occasionally found on the hill west of Boulder. A much larger member of this family (*Euponera hendersoni* Cockerell) is fossil at Florissant. The Dolichoderidae are also represented in our fauna by small ants, but some of them are common. *Tapinoma sessile* Say is known by the small size, dark color, and the scale or node of the abdominal pedicel hardly developed. It also has a peculiar and distinctive odor, something like that of rancid butter. *Dorymyrmex pyramicus* variety *niger* Pergande is another small dark

ant, known by the sharp conical elevation on the posterior part of the thorax above. They nest in open sandy places. *Iridomyrmex analis* André is a very minute yellowish ant, without ocelli. It is common in the southern states, but extends as far north as Boulder. It is related to the destructive Argentine ant, but appears to be harmless.

Our Formicidae are placed in several genera, some of them of unusual interest. The dominant types are *Formica*, *Camponotus* and *Lasius*. The nests of the larger species of *Formica*, commonly seen in the foothills and mountains, are usually covered with small sticks and other vegetable debris. We have forty species and varieties of *Formica* in Colorado, but some of them are hard to distinguish. *Camponotus* usually nests in rotten logs, and may be found everywhere in the mountains. They are often very large ants, with workers of various sizes. The discoidal cell in the middle of the anterior wing of *Formica* and *Lasius* is lacking in *Camponotus*. The species of *Lasius* are small, and nest under stones, where they keep domestic animals, mealy bugs and aphids. The common species (*L. americanus* Emery) is brown, but the subgenus or related genus *Acanthomyops* contains ants which are of a beautiful reddish yellow color, like amber. This group has only three joints (instead of six) in the maxillary palpi, and so has strong claims to be regarded as a genus. We have one species, *Acanthomyops latipes* Walsh, which has curiously modified legs. I have taken it at Boulder.

In the Garden of the Gods and some other localities one may find curious long-legged ants which disappear down vertical tunnels in the ground. If these shafts are excavated, it is found that they are connected with galleries or rooms, to the roofs of which hang numerous globular objects. These objects on closer inspection prove to be worker ants, their abdomens distended to the size and form of a pea, and full of a honey-like substance. They are called repletes, and we recognize the famous Honey Ants, which McCook named *Myrmecocystus horti-deorum*. *Myrmecocystus* means the ant cyst, and horti, of the garden, deorum, of the gods. These repletes are fed by the ordinary workers far in excess of their needs, and are able to regurgitate the sweet substance to supply the rest of the colony when necessary. Hence they are living preserve-jars. The food given to the repletes is

obtained from the exudations of certain galls on the oaks, and probably also from coccids and aphids.

The phenomena of slavery among ants have attracted the attention of many observers. The various varieties of *Formica sanguinea*, red ants with the lower edge of the clypeus more or less notched, enslave the *Formica fusca*. This is done by making a raid on the nest of the dark *F. fusca*, and carrying off the larvae and pupae. The result is to increase the population of the *F. sanguinea* nest, which thus comes to have a mixed population, red and black. However, the *F. sanguinea* is still able to work, so perhaps the term slavery should not be used. We have another kind of red ant, the *Polyergus*, which cannot procure its own food, and is wholly dependent on its slaves the black ants. *Polyergus* can be distinguished from *Formica* by the narrow, falcate and pointed mandibles, which fit it well for fighting. The Colorado *Polyergus* are *P. breviceps* Emery and *P. lucidus* Mayr.

Very small red ants, with only nine joints to the antennae, are *Brachymyrmex heeri* var. *depilis* Emery. They are common at Boulder under stones.

The large group of Myrmicidae, with two nodes or joints in the pedicel or petiole of abdomen, has ten genera in Colorado. The most conspicuous species is the mound building *Pogonomyrmex occidentalis* Cresson, the Bearded Ant. These ants are comparatively large, rust red, with long curled hairs on the under side of the head. The mounds are covered with little stones, of singularly uniform size. The size depends on the ability of the ants to pack them out; if they are too large the tunnel has to go round them. In New Mexico I have found interesting fossil shells on these mounds, and it is alleged that sometimes particles of gold occur. The ants of the genus *Pheidole* are small, but easily recognized by the enormous heads of some of the workers. They store seeds, and the large headed workers are able to crack them. *Myrmica* contains the common rather small red ants, and *Crematogaster* is distinguished by the curious heart-shaped abdomen, convex beneath. *Solenopsis molesta* Say is a very small ant common in the foothill region. It has no spines on the hind part of thorax.

Wasps (Vespoidea and Sphecoidea)

The term wasp (derived from the Latin vespa) is used in a very broad sense, to include two quite distinct series of Hymenoptera. The *Vespoidea*, including the more typical wasps, are themselves exceedingly diverse. The *Sphecoidea* or digger wasps are related to the bees, which appear to have been derived from some ancient sphecoid stock, no doubt during Mesozoic time. Some of the principal families of *Vespoidea* are:

(1) *Masaridae*. Very much like ordinary "yellow jacket" wasps, but easily known by the clubbed antennae. *Pseudomasaris vespoides* Cresson is a large yellow and black species found in Colorado. It makes cylindrical cells of clay, or sand, fastened to the stem of a plant. Other, smaller, species may be found in the mountains.

(2) *Vespidae*. The "yellow jacket" and related wasps, the wings of which fold lengthwise in repose. *Vespa* has the base of the abdomen broad and truncate; *Polistes*, which makes bell-shaped nests, has a narrower abdomen, not broadened at the base; *Mischocyttarus* (often called *Polybia*) has the abdomen with a long petiole. All are commonly found about houses, *Polistes variatus* Cresson being excessively common.

(3) *Eumenidae*. Also with wings folded lengthwise, but averaging smaller, usually with the abdomen conspicuously broadened in the middle. The claws are toothed on the inner side, whereas in Vespidae they are simple. A remarkably handsome member of this group, black and bright red, with black hair, was discovered by Rohwer at Troublesome, and described by him (1915) as *Odynerus margaretellus*. Many Eumenidae have been observed to provision their nests with caterpillars. Many years ago, when I was spending the summer on a ranch in New Mexico, I had a curious experience with one of these wasps. Taking up my pen to write, a green caterpillar dropped out of the hole between my fingers. The next day the same thing occurred, and it was several days before the persistent wasp concluded that my pen was not a suitable place for the rearing of its young.

(4) *Psammocharidae*, the Spider Wasps. Active, long-legged wasps which provision their nests with spiders. In the southwest certain of these wasps are known as Tarantula Hawks; large insects with red wings, which prey on the great hairy spiders. We have many small spider wasps in Colorado, some of them prettily colored.

(5) *Mutillidae*, the so-called Velvet-ants, which are not ants at all, but wasps parasitic in the larval state in the nests of other insects, principally bees. They are remarkable for their brilliant colors, and often long hair, and for the great difference between the sexes. The males are winged like other wasps (but the wings do not fold lengthwise); but the females are entirely wingless, and so unlike the males that it is very difficult to match the sexes. A very remarkable member of this group is *Myrmilloides grandiceps* Blake, which Mr. Clarence Custer found in some abundance at White Rocks near Boulder, in 1926. The males are provided with only minute, rudimentary wings, and have the aspect of females. The case appears to be analogous to that of the Seabright Bantam fowl, experimented on by T. H. Morgan. In the Seabright Bantams the male sexual organs carry an inhibitor for the ordinary male plumage of fowls; and they have the external appearance of hens.

The Sphecoidea are not so varied, and yet include quite diverse elements. The Sphecidae include the Thread-waisted wasps or Mud-daubers, common about houses and in dry places. The base of the abdomen (waist) is slender and thread like, the end more or less enlarged. The mud-daubers make nests of mud, which they provision with spiders. The species of *Sphex* are usually smaller, and nest in the ground, using caterpillars for provisions. They sting the caterpillars in such a way as to paralyze but not kill them, so that they will remain fresh meat for the wasp larvae. Then when the work is completed, they take a little pebble in their jaws to smooth over and flatten out the soil at the entrance to the hole, so that it cannot be found by possible enemies. These extraordinary facts were fully observed and described years ago by Dr. and Mrs. Geo. W. Peckham of

Milwaukee. The Peckhams did not find, however, that wasp instinct was as infallible as some people suppose. There was a difference in the behavior of individual wasps, some showing more ability than others. *Sphex wrightii* of Cresson is a small very slender red species, peculiar for having only two cubital cells in the front wings. It was taken by Mr. Clarence Custer at White Rocks in 1925. Owing to the peculiar venation, this has been referred to the genus *Coloptera*, but it seems not to belong to that Old World group.

The Bembicidae are active wasps which nest in the ground and provision their nests with flies. We have three or four common species, the habits of which have been studied by Mr. S. A. Rohwer. The Crabronidae include many small species, of which the most remarkable is *Crabro latipes* Smith, very common in the mountains. The males of this insect have the front legs expanded into enormous shining plates. The front wings of the Crabronidae have only one cubital cell.

The *Chrysidoidea* or Cuckoo-wasps are not closely related to the wasps described above. They are brilliantly colored insects, usually green or blue, with apparently only three abdominal segments. They are parasitic in the larval state.

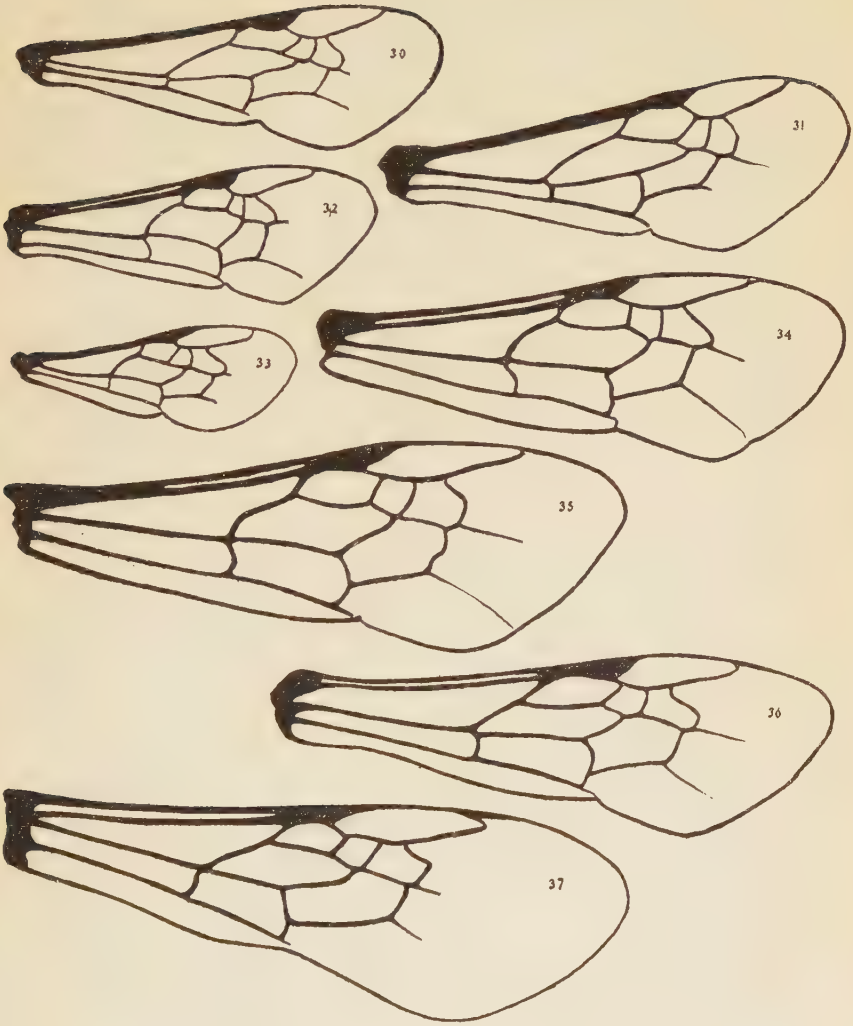
BEES

The bees of Colorado, as at present known, include 779 species. It is a question whether, eventually, Colorado or California will prove to have the greatest number of bees of any State in the Union. Mr. P. H. Timberlake, who is working on the bees of California, especially in the region about Riverside, catches something new every time he goes collecting, to judge from the letters and specimens lately received from him. That we do not know all the bees of Colorado is well shown by the fact that last summer Mr. Chas. H. Hicks went out to collect on the University grounds, near the gymnasium, and obtained *Anthidiellum gilense*, originally described from the Gila River in New Mexico, and *A. robertsoni*, previously known from California. Living here for 20 years, I had never suspected that they existed in the vicinity. At the moment these lines are written, 12 new species of Colorado bees are awaiting publication.

How can we explain this extraordinarily rich bee-fauna? Throughout the world, it is found that dry sunny countries furnish the greatest number of bees. For the most part they nest in holes in the ground, and dry banks and slopes are favorable for their domestic arrangements. Yet the country must possess a large and varied flora, for the bees are dependent on flowers. Colorado is preeminent in both these respects. The species of flowering plants number over 2,500, many of them found in the drier localities. Other regions especially rich in bees are New Mexico, Arizona, California, Turkestan, and North Africa. The deserts of Peru produce many interesting species, but the flora is restricted on account of the aridity, and there are great stretches of country where nothing, or practically nothing, grows.

According to their habits, bees are said to be oligotropic or polytropic, these technical terms meaning that the insect visits few kinds of flowers (sometimes only one kind) or many kinds. The domesticated hive bee and the bumble-bees are polytropic, and to catalogue the flowers they visit is almost equivalent to listing all those in bloom where and when they are flying. On the other hand, there is a genus of very minute bees called *Perdita*. all the members of which are oligotropic. When I first became interested in this genus, in 1895, sixteen species were known. We now know 165, and it is quite certain that many remain to be discovered. The headquarters of *Perdita* is the North American southwest, from New Mexico to California, but Colorado has 30. To the south the extreme outpost is in a dry part of Guatemala, where Mrs. Cockerell discovered *Perdita tropicalis*. To find these little bees, it is only necessary to watch the various desert flowers, and when small insects are observed, sweep over them with a fine net. Special kinds will be obtained on such plants as sunflower, golden rod, resin-weed, croton, spurge, cleome, etc. One of the most remarkable, constituting a new subgenus (*Lutziella*) was discovered by Dr. F. E. Lutz at White Rocks, near Boulder. It visits only the flowers of the prickly-pear cactus, *Opuntia*.

Another classification of bees is based upon the mouth-parts, the characters of the tongue, maxillary blade and palpi or feelers. The more primitive bees, as they are generally understood to be, have short broad bilobed tongues. It was considered that this character radically separated one group from all others, until it



Rocky Mountain Bees (Anterior wings, enlarged)

Fig. 30.—*Nomada vexator;* Fig. 31.—*Nomada* (Gnathias) *lepida;* Fig. 32.—*Augochlora confusa;* Fig. 33.—*Ceratina nanula;* Fig. 34.—*Agapostemon texanus;* Fig. 35.—*Halictus lerouxii;* Fig. 36.—*Andrena bridwelli;* Fig. 37.—*Tetralonia edwardsii vagabunda.*
W. W. Robbins del.

was discovered that in two Australian genera the tongue is sharply pointed in the male, broad and obtuse in the female. Thus, according to the old system, the two sexes of these bees would fall in different subfamilies! At the other extreme are those extremely long-tongued bees, which cannot fold up the mouth parts, but carry them under the body like the beak of a plant-bug. Such a bee is *Melitoma grisella*, gray and of medium size, common about Denver. It visits the flowers of the wild morning-glory, and as that plant is not found at Boulder, the bee is also absent. The most extreme case is that of the South American *Glossura*, in which the tongue projects beyond the abdomen like a tail.

Bees may also be divided into working and parasitic groups. The latter, as for instance the wasp-like *Nomada*, store no food for their young, but lay their eggs in the nests of other bees. The parasitic bees do not constitute a distinct morphological group, but are usually related to and presumably derived from the groups at whose expense they live. Thus *Psithyrus*, which lives at the expense of the bumble-bee (*Bombus*), is so like its involuntary host that entomologists have often confused the two genera. *Coelioxys*, living in the nests of leaf-cutting bees (*Megachile*), is more distinct, especially by its hairy eyes, but is obviously nearer to *Megachile* than to various other parasitic groups. Hence it is quite certain that this parasitism has arisen independently a number of times. Sladen has given a graphic account of *Psithyrus* in the nests of bumble-bees. This insect, which is in effect a *Bombus* which lacks the pollen-collecting apparatus on the hind legs, enters the bumble-bee nest and stings the legitimate queen to death. Then the bumble-bee workers, following their instincts carefully rear the offspring of the usurper.

"The *Psithyrus* queen pays close attention to her new-laid eggs for several hours, giving the (*Bombus*) workers no chance to molest them, but the workers soon get reconciled to them, and henceforth they feed and tend the *Psithyrus* brood with as much devotion as if it were of their own species." How did such parasitic forms arise? Sladen observed in England that occasionally a queen of *Bombus terrestris* enters the nest of the closely related *B. lucorum*, and kills the *lucorum* queen. It then gets the *lucorum* workers to raise its young, precisely as *Psithyrus* would. Such a habit, once firmly established, may finally result in a permanently

parasitic bee, which has even lost the means of feeding its own young, and has in fact no worker cast.

No observations on the biology of *Psithyrus* have been made in Colorado, but we have three species in the mountains. All three have been named twice, one name for the male, another for the female, but the sexes are now correctly associated. In the queen, *P. suckleyi* is known by the black hairs of the head, with at most a little yellow intermixed above. In *P. insularis* the face between the bases of the antennae shows yellow hair, and there is much yellow on the upper part of the head behind. In *P. fernaldae* the face has entirely dark hair, or there may be a very little yellow, but the upper part of the head behind has yellow. There are, of course, other characters, but these are readily seen. In all these females the hind tibiae are convex and hairy on the outer side, instead of being concave and smooth, with long fringes on the margins, as in *Bombus*. In other respects they look just like bumble-bees.

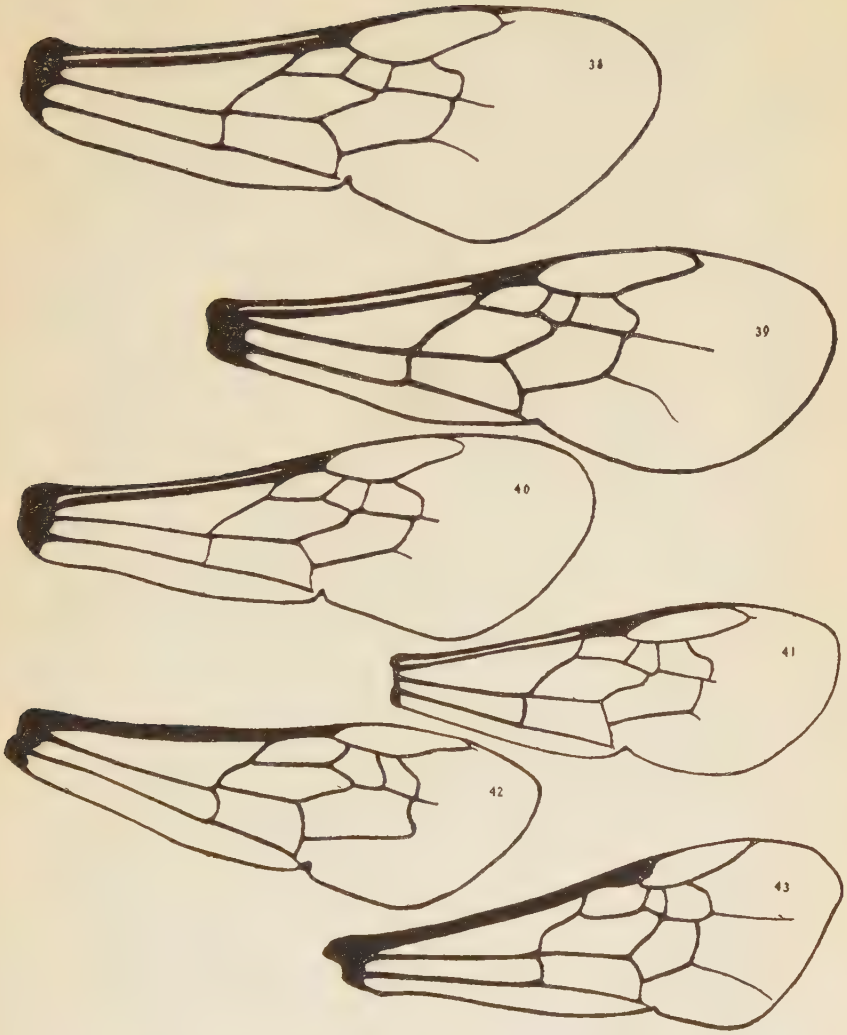
In the study of bees, it is necessary to note particularly the structures for collecting pollen. These of course exist only in the females, and are absent in both sexes of the parasitic genera. In the large group Megachilidae, except for the parasitic members, there is an extensive ventral scopa or pollen brush on the under side of the abdomen. The hairs of the scopa may be white, yellow, red or black, according to the species, but very often they appear magnificently yellow, because full of pollen gathered from plants such as the sunflower and goldenrod. Many other bees possess no distinct ventral scopa, but instead a well-developed one on the hind legs. Other important features are derived from the wings, and these have the advantage of being easily seen with a lens. On examining the upper wings, a thickening will be observed on the upper or anterior margin. This is the stigma; it may be large or small, slender or short and thick. The surface of the wing is divided by the so-called veins into spaces termed the cells. A large one beginning at the stigma and extending toward the apex of the wing is the marginal cell. It is exceedingly long in the honey bee, very short and cut off squarely or obliquely in *Perdita*. Below the marginal cell are the cubital cells, primitively three, but in many bees (as the Megachilidae) reduced to two by the obliteration of one of the cross-veins. So distinctive is the

venation of bees, that the genus can frequently be determined from it at a glance. There is also no difficulty in distinguishing a bee from a wasp by the venation, if one knows the characters. When there is doubt, it may be remembered that all bees, even the parasitic ones, have at least some plumed or feather-like hairs on the body, while no wasps have them. Frequently, however, it is necessary to use a compound microscope.

"An Introduction to the Study of Rocky Mountain Bees," by Cockerell and Robbins, was published by the University of Colorado in 1910. It is unfortunately out of print, and difficult to obtain. Space is not available in the present book to reprint the tables for the identification of genera, but a few notes on the most common or most easily recognized may be given.

(1) *Apis*, the honey bee, is of course domesticated, and comes from the Old World. The common form in Colorado, with largely yellowish abdomen, is the Italian (*Apis mellifera ligustica*). Occasionally black bees (typical *A. mellifera*) are seen. Honey bees differ from all other Colorado bees, except the parasitic *Coelioxys*, in having hairy eyes.

(2) *Bombus*, the humble-bees, or bumble-bees, of which we have 22 species and a number of named varieties. The large size and hairy body are usually quite sufficiently distinctive, but workers may be rather small and species of *Anthophora* may be taken for bumble-bees. In such case it is only necessary to look at the wing, and see that in *Bombus* the second cubital cell is elongated and pointed toward the base of the wing. Some of our species are exceedingly handsome. The common one with a broad red band across the abdomen, occupying the second and third segments, is *Bombus huntii*. I have a specimen of this, with its head covered with pollen masses (pollinia) of an orchid. Mr. S. Knudsen of the North Boulder greenhouse noticed that his large orchid flowers (*Cattleya*) were wilting prematurely. As this caused serious loss, he investigated, and found *Bombus huntii*, which had come into the greenhouse to visit the flowers, and was cross-pollinating them. This was an interesting case, because the bumble-bee had of course never before come in contact with this Brazilian orchid, and yet it behaved as though accustomed to it. In the mountains there is a common bee, red-banded in the fashion of *B. huntii*, but easily separated by the yellow hair



Rocky Mountain Bees (Anterior wings, enlarged)

Fig. 38—*Melissodes pallidicincta;* Fig. 39.—*Xenoglossa angelica;* Fig. 40.—*Xenoglossodes imitatrix;* Fig. 41.—*Diadasia diminuta;* Fig. 42.—*Colletes kincaidii;* Fig. 43.—*Sphecodes pecosensis.*

W. W. Robbins del.

on the scutellum, back of the broad black band across the thorax. This is deeply incised or even divided into two spots, whereas in *B. huntii* the whole scutellum is covered with tawny hair. The second species was named by Cresson *Bombus bifarius;* it is so closely related to a Californian one that some authors regard it as a local race or variety. Still another red-banded mountain bee has the hair on scutellum and abdomen after the fashion of *B. huntii*, but the hair of the face is almost black, whereas it is fulvous yellow in *B. huntii*. This black faced insect, which has a rather short, heart-shaped abdomen, is Cresson's *Bombus rufocinctus*. It is one of the most variable of bees, and we often find the variety *astragali*, in which the broad band across the abdomen is black instead of red. There is an intermediate variety *iridis*, with the band black, mixed with coppery-red hairs. The form with the hair on the second and third abdominal segments entirely deep red, the opposite extreme from *astragali*, is called var. *phaceliae*.

There are two species of less robust bumble-bees, frequently found at rather high altitudes, in which the red band is on segments three and four, instead of two and three. Of these, *B. juxtus* has the yellow of the thorax above without black intermixed, whereas there is a strong intermixture of black in *B. flavifrons*. The latter is especially found at high altitudes.

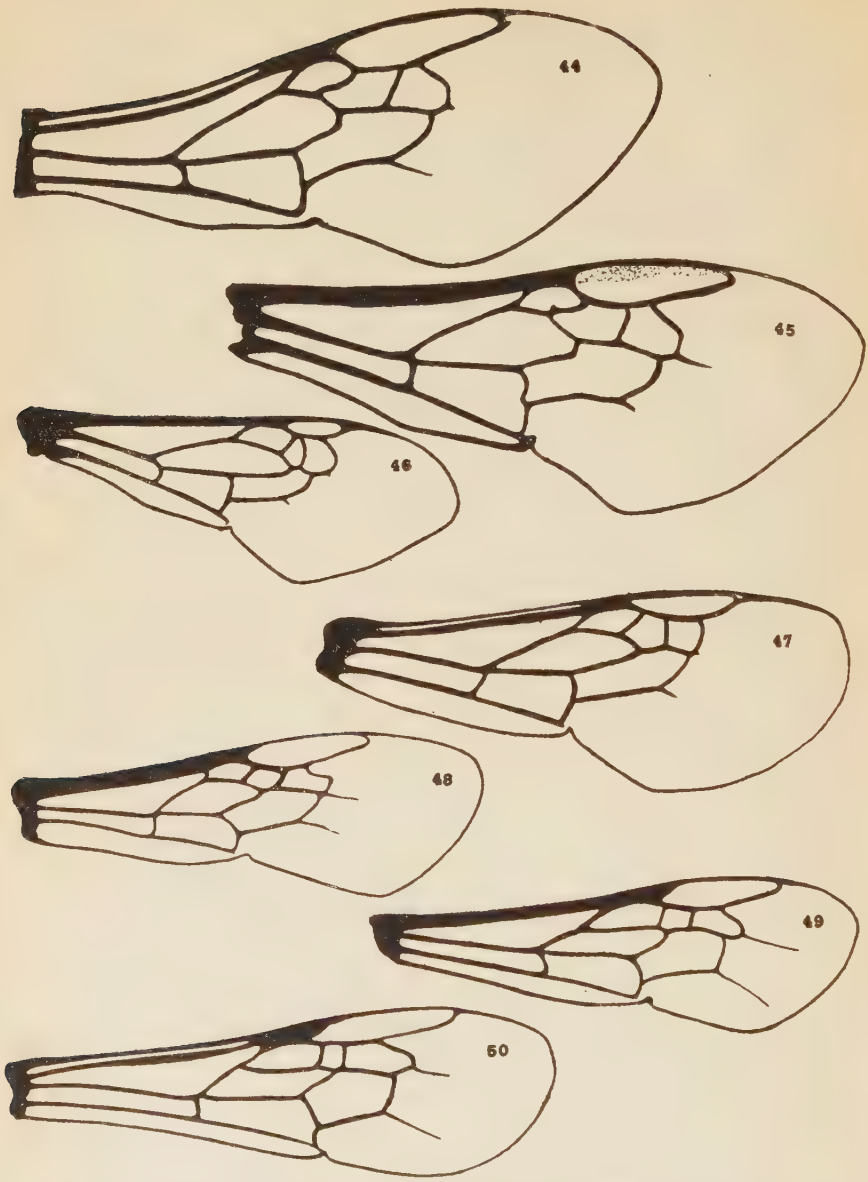
Among the species without red hair, *B. appositus* is especially known by the white hair on the anterior part of the thorax, before the black band. *B. americanorum*, very common in the foothills, is a large bee with the thorax black, the anterior part broadly fulvous-haired; the abdomen fulvous with the apex broadly black. Another very common lowland species is *B. fervidus*, the thorax above with a black band between the wings, the abdomen with the first four segments yellow-haired. One of our most handsome forms is the large *B. morrisoni* of Cresson, with no black band between the wings; the abdomen with the yellow hair covering the first two segments and part of third; the lower edge of the yellow strongly convex. It is named after H. K. Morrison, who explored the western mountains years ago, and discovered many new insects.

(3) *Anthidium* belongs to the Megachilidae, and has a ventral scopa in the females. The abdomen and other parts are marked with yellow, in a pretty pattern; it is especially to be

noted that this is on the surface of the body, and is not due to hair. The French naturalist Fabre long ago remarked that the bees called *Anthidium* belonged to two groups. One used cottony material, scraped from the stems of plants, in preparing its nest, which was in a burrow. The other sort made nests of resin, attached to rocks and other objects. The former is the true *Anthidium;* the latter is now known as the genus *Dianthidium.* There are also structural differences; the easiest to see is the little pad or pulvillus between the claws on the feet of *Dianthidium*, absent in *Anthidium.* The genus *Dianthidium* is also capable of subdivision, and I have separated as *Anthidiellum* a group of small forms, existing both in Europe and America, in which the hind edge of the scutellum is produced and sharp.

(4) *Osmia* is a genus of Megachilid bees, in our fauna nearly always blue or green. Some of the species have very brilliant colors, others are quite dark. Colorado is especially rich in this genus, 80 being recorded up to the present time. The anterior wings, as in all Megachilidae, have only two cubital cells. *Osmia* is being monographed by Miss Grace Sandhouse, who has examined many thousands of specimens for the purpose. Many of the species have been described from one sex, and valuable work can be done by any observer who will find the nests, and thereby associate the sexes. It will doubtless then appear that in some cases both sexes of a species have been described, but under different names. Rather small bees more or less like *Osmia* and *Anthidium*, but quite without a ventral scopa in the female, belong to the parasitic genera *Stelis* and *Chelynia.* Mr. Chas. H. Hicks has made observations which indicate, with little doubt, that *Chelynia monticola* is parasitic in the nests of the brilliant green *Osmia fulgida.*

(5) *Megachile* includes the leaf-cutting bees, which often damage rose bushes by cutting semi-circular pieces out of the leaves. The bee does not eat these leaf-fragments, but uses them to build its cells, in which the young will develop. The habit is a very old one, for it not only may be observed on every continent, but fossil in the Miocene shales at Florissant we found a leaf-cutting bee (*Megachile praedicta*), and also a leaf cut in the characteristic manner. The latter was figured in Nature, Feb. 10, 1910. Our species of *Megachile*, of which there are 33, have the body surface



Rocky Mountain Bees (Anterior wings, enlarged)

Fig. 44.—*Psithyrus insularis;* Fig. 45.—*Bombus huntii;* Fig. 46.—*Bombomelecta fulvida;* Fig. 47.—*Anthophora occidentalis;* Fig. 48.—*Melissodes obliqua;* Fig. 49.—*Andrena argemonis;* Fig. 50.—*Nomia nortoni.* W. W. Robbins del.

black, not metallic as in most Osmia. There is no pulvillus between the claws, such as exists in *Osmia* and related genera.

(6) *Coelioxys* is a curious genus, parasitic in the nests of *Megachile*, rather easily known by the hairy eyes. The females have the end of the abdomen lengthened and sharply pointed; in the males it is short and spiny. We have 22 species, but their association with particular host-bees has never been ascertained, with the exception of a couple which were studied by Graenicher in Wisconsin.

(7) *Melissodes* and *Tetralonia* belong to the Eucerine Anthophoridae, and are peculiar for having the antennae extremely long in the males, but short in the females. The males also nearly always have the face yellow or whitish, while in the females it is black. Thus the sexes are surprisingly different, and have sometimes been described as different species. In all, the tongue is very long, and there are three cubital cells in the front wings. *Tetralonia*, with black antennae and six-jointed maxillary palpi, appears in the spring or early summer. Later in the summer we find numerous kinds of *Melissodes*, mostly with the antennae reddish or bright ferruginous beneath, and all with the maxillary palpi four jointed. The primitive number of joints in the maxillary palpi of bees is six, and in the course of evolution we find these numbers variously reduced. Thus *Melissodes* is more modified than *Tetralonia*. A closely related genus, *Xenoglossa*, has species which may be found in the flowers of squash and similar plants. Its maxillary palpi have five joints.

(8) *Anthophora*, the type of Anthophoridae, has sixteen Colorado species. Several of them are large and robust, almost like humble-bees, but easily known from them by the wings, and the light surface of the face in the males. The tongue is very long, and there are six joints to the maxillary palpi. The male antennae are not unusually long. These bees nest in holes in banks, and make a little extension or porch over the opening. The work is all done by the females, but the males may sometimes be seen with their light faces at the openings of the burrows, serving as doors to keep out intruders. In spite of all precautions, a very curious beetle (*Leonidia neomexicana*) is able to live as a parasite in the nests. It cannot fly, but its larvae are doubtless transported clinging to the bodies of female bees.

A parasitic bee, Bombomelecta johnsoni *Ckll.* Type. Evelyn Moore del.

(9) *Triepeolus* is richly represented by 30 species, all parasitic, probably without exception in nests of Anthophoridae. These bees are elegantly marked with light bands and spots, which appear at first to be on the actual surface, as in *Anthidium*. Closer inspection shows that they are due to a minute felt-like tomentum, which can be readily scraped off. The maxillary palpi have three joints, but in the closely related *Epeolus* there are only two joints. There are in Colorado several other related genera of parasitic bees, which we will not attempt to describe in this place. A very peculiar one (*Neolarra*) was originally described as a wasp.

(10) *Nomada* is another parasitic genus, the species prettily marked on the actual surface with yellow, whitish or ferruginous red. They look like small wasps, and are often regarded as such. The maxillary palpi are six-jointed, instead of being highly modified as in *Triepeolus*. We have 74 species in Colorado, but very little is known about their habits. It is probable that nearly all infest the species of *Andrena*, which may be found nesting in the ground.

(11) *Panurginus* consists of small black bees with only two cubital cells, and the marginal cell truncate (as though amputated) at the end. The males have conspicuous light face markings. We have 22 species known at the present time, some of them quite common in the mountains. The related *Spinoliella* differs principally by the light markings of the abdomen. The genus *Perdita*, already mentioned above, differs from these by the much shorter marginal cell. Most of the species are gaily marked in wasp-like fashion, but very small.

(12) *Halictus* is found all over the world, wherever bees can live. Hundreds of species are known, of which 79 have been reported from Colorado. While many species are black, many show green or bluish colors, especially on the head and thorax. The genus may be recognized as a rule by the pointed marginal cell, three cubital cells, and the basal nervure (which extends downward obliquely from the corner of the first cubital cell) strongly arched or curved. They nest in the ground. The two

sexes hatch out during the summer, but the males die in the fall, whereas the females winter in the ground, and come out in the spring or early summer to make their nests, unhampered by the unemployed males. One species visits Evening-primrose flowers after sundown.

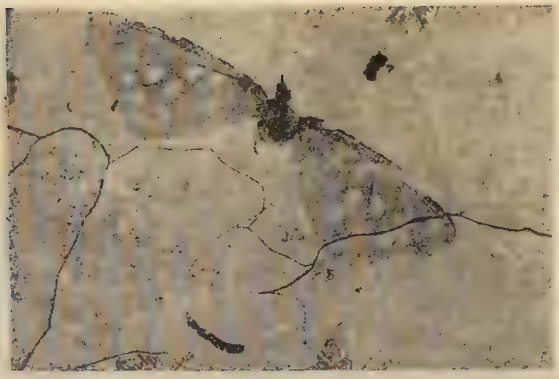
(13) *Andrena* differs from *Halictus* in being larger on the average, with the basal nervure not distinctly or conspicuously arched. The females have peculiar depressions, the facial foveae, at the sides of the face and the front close to the eyes. They are best seen when looked at from above. The species are even more numerous in Colorado than those of *Halictus*, 119 being on record. This is probably due to the fact that many are oligotropic, or associated with particular plants, while few *Halictus* are thus restricted. The Rev. F. D. Morice of Woking, England, is a well known student of bees. When I visited him several years ago he led me round his garden, and pointed out how he had planted different wild flowers, each to attract some species of *Andrena* which flew in the vicinity. A Colorado naturalist could do the same thing, by planting Oregon-grape, wild gooseberry, willow, yellow violet, and so forth.

(14) *Colletes* is a genus of bees with short, broad bilobed tongue, adapted for lapping. The species are of moderate size, and may be taken for *Andrena* if the mouth parts are not examined. There is however a good character in the wings; the large cell below the second and third cubitals bulges outward at the end, instead of being squarely cut off, as it is in most bees. The Colorado *Colletes* at present number sixteen, but it is certain that more remain to be described. They are adapted to get nectar from only very shallow flowers, but sometimes they obtain it without paying for their meal, that is, without doing anything to cross-pollinate the flowers. It was noticed that many blue *Mertensia* flowers had a large hole in the tube, cut by some bee with its mandibles, to get at the nectar. After much watching, the culprit was found, it was *Colletes nigrifrons*, a short tongued bee which could not otherwise obtain nectar from tubular flowers.

(15) *Hylaeus* (also called *Prosopis*) has 21 Colorado species, small black insects, usually with conspicuous markings on the face. They are not noticeably hairy, and do not look like bees.

The tongue is short, as in *Colletes*. There are only two cubital cells; the stigma is well developed and the marginal cell is pointed. These little bees nest in the dead stalks of various plants; from such material it is possible to breed not only *Prosopis* but also the little dark green bees of the genus *Ceratina*, of which we have three Colorado species.

The study of wild bees still affords great opportunities for research and discovery. In the summer time, as we travel through the mountains or across the plains, the flowers are alive with butterflies and bees. The butterflies, beautiful and interesting as they are, resemble the birds in having been rather exhaustively studied. There is, indeed, much work to be done on even these well-known groups, but the species have been described, and the distribution and habits are rather accurately known. With the bees it is a different matter. There have been few students, and it is still possible to discover new species even in Boulder, where I have paid attention to this group for twenty years. Many new facts about distribution are continually coming to light. Very much remains to be done in breeding the insects, describing their habits and matching the sexes. The host-relations of our parasitic bees are hardly known at all. Many important details of structure are still to be described and illustrated. The larvae of the bees have good characters, but we know little of them. Various remarkable insects of other orders are parasitic on bees, and these should be bred and studied. Unfortunately there is at present no manual of North American bees, though there are numerous revisions of particular genera or parts of genera. Were a manual to be prepared today, as complete as we could make it, it would soon be out of date, owing to fresh discoveries. It is pleasant and convenient for the student to find a book which will solve all his difficulties, but when he finds this, it means that the work has already been done. To the real naturalist it is more agreeable to be a pioneer, treading the little known paths where discoveries may be made every day.



1. Fossil Butterfly (*Chloritppe wilmattae* Ckll.) from the Miocene shales of Florissant. Actual size two and three-eighths inches across the wings.

Coulson Photo

2. (Upper side). 3. (Down side). *Basilarchia weidemeyerii* Edwards, aberration *nigerrima* Ckll., Boulder, Colorado, found by Elven Nelson.

Specimen in U. S. National Museum

Nat. Mus. Photo

Chapter 10

BUTTERFLIES

The butterflies of Colorado are numerous and varied, including many large and handsome species. How long they may have existed in this region we do not know, but certainly for many millions of years, since we find them fossil at Florissant. These fossil butterflies all represent extinct species, and with one exception (*Chloripe wilmattae*) are little related to those now living in Colorado. The present-day butterflies of the Rocky Mountains belong for the most part to what are called Holarctic genera, that is to say genera found in the northern regions of Europe, Asia and America. Indeed, certain of the species are identical with those found in England. Every English butterfly-collector hopes that sometime in his life he will have the great luck to capture a specimen of the Camberwell Beauty (*Euvanessa antiopa*). It was so called because it used to be found at Camberwell, a suburb of London, now all built up and quite unsuited for butterflies. It is a large broad-winged insect, on the upper surface of a dark, rich chocolate color, and with a broad, pale yellow border. Where the light border joins the darker color, lilac-blue spots are set on a black ground. Both front and hind wings have prominent angles or projections on the outer margin. This butterfly, so rare and highly esteemed in England, is with us a common object, and may be captured almost any day in summer. It occurs in the mountains and foothills, and the very spiny caterpillars may be found on the willow. The common name for it in America is Mourning Cloak. To the biologist such an insect is of special interest as representing a very conservative type which has spread far and wide without changing its characters or giving rise to a series of related species. Thus it contrasts with *Argynnis*, the genus of Silver Spots, which includes so many closely similar species and races that even the most learned authorities are perplexed in dealing with it. A still more cosmopolitan butterfly, also common with us, is the Painted Lady (*Vanessa* or *Pyrameis cardui*). The wings are variegated with black and rosy reddish in an intricate pattern, and near the apex of the front wings may be seen a curved row of white spots on a

black ground. It is famous for its migrations; in England it appears in numbers in certain years, flying over from the Continent. The spiny larvae may be found on thistles, but also not rarely on the garden hollyhock. Related to the Painted Lady, but not so common, is Hunter's Butterfly (*Vanessa virginiensis* of Drury). It may be readily known by the larger submarginal black spots, some with lilac centers, on the hind wings, as well as the large eye-like spots on the under side of the same wings. The caterpillar feeds on plants of the "everlasting" type, *Gnaphalium* and *Antennaria*. A still rarer species, which has been taken at Denver, is the so-called West Coast Lady, *Vanessa carye* (not *caryae*, as sometimes spelled). It is very much like the Painted Lady, but the rosy-fulvous area near the lower corners of the front wings is a separate patch, not united with the band which crosses the wings. The under side does not have the large eye-spots of *V. virginiensis*. According to Seitz, it is especially distinguished from *V. cardui* by the subapical band before the white spots on front wings, which is tan colored instead of white. This is not satisfactory, because it is often similarly colored in American *V. cardui*, and in a specimen of *V. carye* I collected at Valparaiso, Chile, in August, the upper end of this band is white. In South America, *V. carye* is common; I found it in Chile, and saw it about Arequipa, Peru.

Closely related to these insects is the American Tortoise-shell, *Aglais milberti*. It is smaller than the butterflies just described, and has the inner part of the wings above nearly all black, but with red marks on the upper wings. Beyond the black is a very broad red band across both wings, while the margin is again dark. The wings have the pointed projections characteristic of the group. In the Rocky Mountain race, *A. milberti subpallida*, the red band is strongly flushed with yellowish or very pale buffy. The caterpillar lives on stinging nettle. In England they have a closely related species, called the Small Tortoise-shell, the larva of which also feeds on nettle. They have also a larger insect, the Large Tortoise-shell, in which the wings show large black spots, but the inner half or more is not black or very dark. In Colorado this is represented by a very similar insect, the California Tortoise-shell, the larva of which feeds on *Ceanothus*. It is a western species evidently derived from ancestors which came from Asia by way

of Alaska, but it extends eastward as far as the Rocky Mountains. The scientific name is *Aglais californica*.

Following an old English custom the name Admiral is given to certain large butterflies, in which the front wings are obliquely crossed by a bright red or pure white band on a black ground. In the Red Admiral (*Vanessa atalanta*), which is really related to the Painted Lady, this band is red, and there is a broad red band bordering the hind wings. There are numerous white spots near the tips of the front wings. This fine butterfly, the caterpillar feeding principally on nettle, is very common in Europe, and not rare in Colorado. I have seen it on the University of Colorado campus. The Rocky Mountain White Admiral (*Basilarchia weidemeyeri* of Edwards) is black and white, with very broad white bands crossing both the wings. It is very common in our mountain valleys; the caterpillar, which is not spiny, lives on cottonwood. There is no close relationship with the Red Admiral, but curiously enough, there is another *Basilarchia* (*B. archippus*), called the Viceroy, which presents a totally different appearance. The wings are rich red-brown, with a dark margin on which are little white spots. One might take it for an undersized Milkweed Butterfly, but it differs conspicuously by having a black line crossing the hind wings. This is regarded as a case of "mimicry." The quite unrelated Milkweed Butterfly is distasteful to vertebrate enemies, and it is supposed that the Viceroy gains some protection by resembling it. The Viceroy is not common with us, but it has been taken at Boulder by Hite and at Pueblo by Nash, and on the western slope at Newcastle by Robbins.

An easily recognized genus of butterflies is *Polygonia* (also called *Grapta*), the Angle-wings. The front wings have the outer margin deeply scalloped, with prominent lobes or angles, while the hind wings have short tails arising from the middle of the margin. The general color of the upper surface is rich ferruginous red with numerous black spots. On the under side of the hind wings, in some species, is a silver C, whence the name Comma-butterfly for the common English representative. When the wings are closed, these butterflies can hardly be distinguished from an old dry leaf. We have at least four species in Colorado; they are all figured in Holland's Butterfly Book, Plate XIX, f. 1, 2, 7, 8, 14, 15, and Pl. XX, f. 1, 2.

The species of *Argynnis*, known as Silver-spot Butterflies or Fritillaries, have a rather uniform appearance, above more or less rich rusty red (ferruginous) with black spots and short bars or stripes, and on the under wings below with beautiful shining silver spots. The spiny larvae mostly feed on the leaves of violets. Many species live in Colorado. One of the finest is the large *A. edwardsi* of Reakirt, which has the under side of the hind wings olive green, more or less streaked with pale yellow, and the silver spots extraordinarily large and brilliant. Specimens before me were taken by Max Dings near Long's Peak. It was named in honor of W. H. Edwards of West Virginia, who was for many years the leading authority on North American butterflies. A common butterfly easily confused with *Argynnis* is *Euptoieta claudia*, belonging to a genus which seems to have originated in Central or South America. On the upper side the general effect is that of a fritillary, but there is a zigzag black line crossing the wings, to the outer side of which is a pale band. There are no silver spots beneath. The genus *Brenthis* consists of small butterflies sometimes included in *Argynnis*, but strikingly different in appearance. *B. myrina* has shining silver spots beneath, but *B. helena*, which occurs at high altitudes, has the hind wings beneath variegated with yellow, rust-red and white, not shining. Mead in 1875 said of *B. helena:* "It inhabits the highest peaks. . . At 13,000 and 14,000 feet though the temperature must descend below the freezing point every night through the summer, the species seems perfectly at home, and is often more abundant than below." Another species reported by Mead, as especially occurring near Fairplay, was *B. triclaris;* but recently it has been considered by Barnes and McDunnough that this was an error of identification, and they have proposed the name *B. aphirape alticola*. The typical *B. aphirape* is European. There are two other genera of small, mainly ferruginous and black butterflies, which are well represented in Colorado. These are *Melitaea* (from which Scudder's *Euphydryas* is often separated) and *Phyciodes*. A common species of *Phyciodes* (*P. ismeria*) comes from spiny larvae feeding on sunflower.

The genus *Chlorippe*, the larvae of which feed on *Celtis* (hackberry), is represented in Colorado by *C. montis* of Edwards, as understood by Holland, but Barnes and McDunnough (1913)

say it is really a form of *C. antonia* of Edwards. The true *C. montis*, it appears, is from Arizona, but Edwards, when describing it, referred to a specimen taken by Dodge at Boulder, Colorado, then supposing it to be the same thing. It seems, however, that both *antonia* and *montis* may be regarded as races of the *C. celtis* of the Mississippi Valley. Our butterfly has the upper side a sort of olive-brown, with many light spots, and some black spots ringed with light. The anterior wings are rather conspicuously produced and pointed. All the above butterflies belong to the great family Nymphalidae, in which the front legs are reduced and useless for walking, so that the insect walks on four legs. Two other families possessing this character are the Danaidae and Satyridae. The former, in which the antennae are without scales (scaled in Nymphalidae), includes the common large Milkweed Butterfly, well known to nearly everyone. It is famous for migrating in vast numbers at certain times; there is a very good exhibit illustrating this in the American Museum of Natural History, New York. One would think that the scientific name of such a common and conspicuous insect would be easily settled, but it has given rise to endless disputes. Very recently (1924) Barnes and Benjamin have reinvestigated the subject, and declare that the name should be *Danaus menippe*.

The Satyridae may be defined as derivatives from the Nymphalidae, with grass-feeding larvae, which are not spiny; the butterflies usually dull brown or reddish, with ocellated spots, and with some of the veins of the front wings swollen at base. The last segment of the larva is bifurcate, which is also true of *Chlorippe*. We have in Colorado seven genera of these Satyridae (Satyrs, or Meadow Browns). One of these, *Oeneis*, includes butterflies which live high in the mountains, being often caught at timberline, though they also occur much lower down. Their coloration is such that when they light on the rocks, and allow their wings to fall to one side, they are almost invisible.

The Papilionidae, or Swallow-tails, typified by the great genus *Papilio*, are usually easy to recognize. The hind wings have conspicuous tails in most of the species, but they may be small or absent. The larvae of *Papilio* have a remarkable bifurcate scent organ, which they can thrust out just behind the head. Some of them, in the early stages, look very much like bird

excrement, but when they are large and cannot escape notice they may find protection by being able to emit a disagreeable odor. The following key will enable the student to separate the Colorado swallow-tails:

Tail of hind wings very short, light markings very pale. . *indra* Reakirt.

Tail or tails of hind wings long . . . . . 1.

1. Each hind wing with two tails, and the inner angle also prolonged; large species with yellow background and stripes (except submarginal bands) not heavy . . *daunus* Boisduval.

   Each hind wing with one tail . . . . . 2.

2. Anterior wings greenish black without spots or bands, hind wings more decidedly green . . *philenor* Linnaeus.

   Anterior wings with at least some conspicuous markings . . . 3.

3. Middle of hind wings crossed by a suffused pale bluish band, but without yellow or white band or area . . *troilus* Linnaeus.

   Hind wing with at least some conspicuous light bands or areas. 4.

4. Ground color of wings creamy white . . . . . *eurymedon* Lucas.

   Ground color of wings yellow . . . . . 5.

5. Neither anterior nor posterior wings with an extensive black basal area, but extreme base of anterior wings and a band along inner margin of hind wings black; large species . . . . *rutulus* Lucas.

   Base of anterior wings (at least) broadly black . . . . . 6.

6. Much more than half of hind wings, before the broad black band, yellow . . . . . 7.

   About half of hind wings, before the dark band, yellow; yellow band on anterior wings conspicuously broadening below . . . . . *bairdi hollandi* Edwards.

   Much less than half of the hind wings, before the dark band, yellow . . . . . 8.

7. Dark band of hind wings with large blue spots; marginal yellow spots larger; larger species . . *bairdi brucei* Edwards.

   Dark band of hind wings with small blue spots; smaller species . . . *zelicaon* Lucas.

8. Larger; inner edge of yellow band on hind wings strongly curved . . . . *bairdi* Edwards.

Smaller; inner edge of yellow band on hind wings, except for the indentations, practically straight . . *polyxenes* Fabricius (*asterius* Cramer).

P. daunus and *P. rutulus* are common along the foothills about Boulder and elsewhere. *P. polyxenes* and *P. zelicaon* are also widely distributed. *P. eurymedon* has been taken on Pike's Peak by Reakirt, at Rye in Pueblo County by Nash, and in Boulder Canyon, near the town, by Gillette. *P. indra* was recorded from Boulder as long ago as 1883, and is also found on Pike's Peak. *P. philenor* was taken by Nash at Pueblo and Rosita. *P. troilus* is included because I saw a specimen in my garden at Boulder, Sept. 21, 1924. I got quite close to it and could not be mistaken, but it was far out of its ordinary range. *P. bairdi* and its varieties or races are found in western Colorado; Holland suggests that *P. brucei* originated as a hybrid between *P. bairdi oregonia* and true *P. bairdi*. An additional character for the *P. hollandi* form is that the abdomen is always striped laterally with yellow, or wholly yellow. The larvae of all these *P. bairdi* races feed on Umbelliferae, and the same is true of *P. polyxenes* and *P. zelicaon*. *P. rutulus* and *daunus* feed on various shrubs, but never on Umbelliferae.

Structurally related to the Swallow-tails, but utterly different in aspect is the group of Apollo butterflies, the genus *Parnassius*. They occur on mountains in Europe, Asia and North America, and are easily recognized by the broad rounded wings, with red (or sometimes yellow) and black spots on a white ground, and frequently broad gray bands, or a gray suffusion over most of the wing. The red spots, best developed on the hind wings, are ringed with black. The antennae are unusually short. *Parnassius smintheus* of Doubleday and Hewitson is common in Colorado, the larva feeding on the yellow-flowered stone-crop. A dark form of the female, the *P. smintheus hermodur* of Henry Edwards (see Holland, Butterfly Book, Pl. XXXIX, f. 6), was taken by Mr. S. A. Rohwer on Arapahoe Peak, above timber line, Sept. 1, 1906. The accompanying males were not darkened, and it is curious that the high alpine race or variety should be modified in only one sex. The common form of lower altitudes in Colorado is not strictly identical with the original *P. smintheus*, which came

from British America; it has received the name *P. smintheus sayi* Edwards.

In Europe, amateur collectors are greatly interested in the variations and local races of *Parnassius*, with the result that many minor forms have received names. Recently, some of our Colorado specimens have come into the hands of these specialists, and variations have been named *leonhardii* Ruehl and *fermata* Bryk, the latter said to be from Denver. Some day, students of genetics will take to breeding and crossing varieties of *P. smintheus*, and then results of biological interest will certainly be obtained.

The extensive family Pieridae consists of mostly white or yellow butterflies, more nearly allied to the Swallow-tails than to any other group. The hind wings are quite without tails, and the claws on the feet are bifid or two-branched, instead of being simple as in Papilionidae. The following artificial table will make it possible to recognize most of the forms.

Large bright yellow butterflies without dark markings . . . 1.

Yellow or yellowish butterflies, with distinct black markings, or at least black spots on front wings . . . . . 2.

Bright or deep orange, or yellow suffused with orange, and with dark markings . . . . . 9.

White butterflies . . . . . 10.

1. With an orange patch on anterior wings (taken by H. G. Smith, Jr., in Arapahoe County, a straggler from the south) . . . . *Catopsilia philea* Linnaeus.

   Without such orange patches (a straggler from the tropics, taken at Rosita) *Catopsilia eubule* Linnaeus.

2. Apical region of anterior wings with a bright orange patch; small butterflies. (Boulder, Tolland, etc.) . . . . . *Anthocharis sara julia* Edwards, female.

   No such orange patches . . . . . 3.

3. Apex of anterior wings broadly black; very small butterflies, expanse an inch to an inch and a quarter (common in the mountains and on the plains) . . . *Nathalis iole* Boisduval.

Outer margin of anterior wings with a solid black band . . . 4.

Outer margin of anterior wings with a black or grayish band on which are yellow spots (common) . . . . . *Eurymus eurytheme eriphyle* Edwards, female.

Outer margin of anterior wings with no distinct band, at most a blackish suffusion . . . . . 8.

4. The black band deeply excavated in the middle by the yellow . 5.
The band not excavated by the yellow . . . . . 6.

5. The yellow area with a black spot, the whole with the aspect of a dog's head in outline (a straggler from the south and east, taken by Nash at Pueblo) . . *Zerene caesonia* Stoll.

The yellow very pale, and without a black spot; no black at base of wing (a southern species, occasionally migrating in great numbers, and temporarily common in Colorado, as far north as the mountains of Boulder County) . . . . . *Eurema mexicana* Boisduval.

6. Hind wing with a very broad blackish band, fading toward inner angle. (a straggler from the south, taken in Pueblo and Custer counties) . . . *Eurema nicippe* Cramer, female.

Hind wing with narrow or evanescent yellow band, and anterior wings more pointed . . . . . 7.

7. Hind wing beneath pale greenish gray, with a light dot (common in the mountains) . . *Eurymus alexandra* Edwards, male.

Hind wing beneath sulphur yellow, with a silver spot bordered with reddish; a whitish spot on upper side of hind wings (common high in the mountains) . . . . . *Eurymus scudderi* Reakirt, male.

Hind wing beneath pale dull yellow or greenish yellow, with a discal spot; an orange spot on upper side of hind wings . . *Eurymus curytheme eriphyle* Edwards.

8. Larger, anterior wing about 30 mm. long, color distinctly yellow . . . *Eurymus alexandra* Edwards, female.

Smaller, anterior wing about 24 mm. long, color exceedingly pale yellow or white . . *Eurymus scudderi* Reakirt, female.

9. Anterior and posterior wings with broad black bands, the inner edge of the band on front wing strongly concave, forming half a circle . . . . . *Eurema nicippe* Cramer, male.

Inner edge of broad black band on anterior wings undulate, but not concave, forming half a circle; the band in females spotted with yellow . . . . *Eurymus eurytheme* Boisduval.

Deep orange, appearing almost brown in flight (at very high altitudes) . . . *Eurymus meadi* Edwards.

10. With bright orange patch near apex of fore wing . . . . . *Anthocharis sara julia* Edwards, male.

Wings without such patches . . . . . 11.

11. Hind wings beneath beautifully marbled (not longitudinally streaked) with green, this color really due to a mixture of yellow and blackish scales; small butterflies . . . . . 12.

Hind wings not thus marked . . . . . 14.

12. Hind wings beneath with the green consisting roughly of three transverse bars, the larger two joined by a cross-bar forming a sort of H (Boulder, taken by F. Becker, May 20, 1922) *Zegris olympia* Edwards.

Hind wings beneath with much more green, approaching a checker-board pattern . . . . . 13.

13. Larger, expanse between 40 and 50 mm. (common; larvae on Cruciferae) *Euchloe ausonides* Boisduval.

Smaller, expanse about 30 to 35 mm., green markings on under side of wings heavier, and the ground color pure white (more greenish white in *ausonides*) (a Californian form, reported by Edwards as extending to Colorado) *Euchloe creusa hyantis* Edwards.

14. Anterior wings with upper apical margin broadly black, on which are white spots; a curved black band along upper margin of wing (locally common in the mountains, the caterpillar feeding on pine. Taken by S. A. Rohwer in Four Mile Canyon and along Lefthand Creek in Boulder County) . . . . *Neophasia menapia* Felder.*

Anterior wings not thus marked . . . . . 15.

15. Anterior wings with a broad black border, spotted with white, extending from apex to base of outer margin . . . *Eurymus eurytheme*, female form *alba* Strecker.

Anterior wings without such a border . . . . . 16.

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*For a good account of this butterfly and its injury to pine trees, see J. C. Evenden, Journ. Agricultural Research, 1926, p. 339.

16. Wings above practically without, or with very faint markings . . . . . 17.
    Wings above with conspicuous markings . . . . . 18.
17. Anterior wings each with a black spot, on which is a light dot. . . . *Eurymus scudderi* Reakirt, female.
    Anterior wings without such discal spots (common) . . . . . *Pieris napi oleracea* Harris, male.
18. Hind wings beneath very pale yellowish, without dark markings; female with two conspicuous dark spots on disc of fore wing above (the European cabbage butterfly, introduced, now very abundant) . . . . *Pieris rapae* Linnaeus.
    Hind wings beneath conspicuously marked . . . . . 19.
19. Wings above with few spots, much resembling *P. rapae*, but hind wings beneath, at least, marked with gray stripes along the veins . . . . . *Pieris napi oleracea* Harris, female.
    Wings above more conspicuously spotted, with at least a series of black or gray spots along the outer margin . . 20.
20. Under side of hind wings with heavy greenish-gray markings along the veins, yellow on the actual veins, but these radiating markings broadly interrupted on disc by a white subcrescentic area (widely distributed in the mountains, and extending to California) . . . *Pieris beckeri* Edwards.
    Rather similar but smaller, the markings on under side grayer, less yellow, and not entirely interrupted; discal spot on fore wings above narrow, little or not larger than subapical spot (large and subquadrate, with a white pupil, in *beckeri*) (widely distributed; at Boulder taken by Elsie Foster, May 8, 1922) . . . *Pieris sisymbrii* Boisduval.
    Male very lightly marked, almost pure white above, but the discal and subapical marks present, pale gray; female marked much as in the last, wings more pointed, marginal spots of anterior wings triangular, with base on margin (common, perhaps better considered a western race of the next) . . . . . *Pieris occidentalis* Reakirt.
    More heavily marked than *occidentalis*, the male with very distinct discal spot, the female with large discal spot extending to the costal margin (which is not the case in *beckeri*); stripes along veins on under side of hind wings

in this and *occidentalis* continuous. (A common species of the Eastern States, extending into Colorado; it has been taken on the University of Colorado campus) . . . . *Pieris protodice* Boisduval and Leconte.

Pieris napi is a common Old World species, represented in North America by various forms which have received names. Four of these have been reported from Colorado. Peculiar dwarf females of *P. protodice*, with the anterior wings 19 mm. long, and the hind wings beneath very heavily marked, were taken by C. F. Leach in the foothills about seven miles west of Sedalia. The first was seen as early as February 12, and it is to be presumed that the cool weather influenced the size. The Colorado form of *Euchloe ausonides* has received the names *coloradensis* Henry Edwards and *montana* Verity, but there is little to distinguish it. *Eurymus scudderi* has the females white or pale yellow, the latter form being called *flavotincta* Cockerell. Our most interesting Pierid butterfly is *Eurymus* (or *Colias*) *eurytheme*, the larva of which feeds on alfalfa, clover and related plants. This species is polymorphic, and appears also to be imperfectly differentiated from the common sulphur butterfly of the Eastern States, *Eurymus philodice*. Formerly, the matter appeared perfectly simple; there was a yellow species in the East, and an orange one in the West. Both produced white females from time to time, exactly as in related European species. However, in 1876, W. H. Edwards described a yellow form, which he called *eriphyle*, from British Columbia. In 1883 he set forth still another yellow type, called *hageni;* this he had from Pueblo, Colorado. Later researches indicated that *eriphyle* and *hageni* were practically the same thing, and Edwards proved by breeding that this was a form of the orange *E. eurytheme*. Late in the fall, and in greater numbers early in the spring, there occurs the form *autumnalis* Cockerell, smaller, with narrower dark borders, and the hind wings beneath grayish green. This is probably a direct result of the cooler weather, and not a genetically distinct form. These *eriphyle* forms are exceedingly similar to the *E. philodice* of the Eastern States and since *philodice* has been spreading westward, it becomes difficult to decide the exact status of some specimens. *E. philodice* is on the whole a clearer yellow, with blacker borders, especially those of the hind wings of the female.

Professor J. H. Gerould carried on some extensive experiments in hybridizing *E. eurytheme* (from Arizona) with *E. philodice* (from New Hampshire). The offspring were yellow flushed with orange, and this was even the case when he used white females of *E. eurytheme*, showing that the latter carried the factor for orange in the germ-plasm. Many years ago, W. H. Edwards proposed as species what he called *ariadne* and *keewaydin*. The form *ariadne* is just like Gerould's hybrids, and flies where the orange and yellow forms approach each other or meet. The one called *keewaydin* is larger and more strongly suffused with orange, being intermediate between *ariadne* and the large brilliant orange form which Boisduval named *amphidusa*. We may suspect that these orange-flushed insects had their origin as hybrids, or are derived from hybrid stock, but they occur not only along the eastern border of the range of *E. eurytheme*, but also across the western country to the Pacific. It appears that *ariadne* is the spring form, not genetically distinct from *keewaydin*. In Custer County, Colorado, I found a race which I named *intermedia*, larger than *keewaydin*, expanse of wings in female over two inches, color of wings pale sulphur, with distinct orange patches on the front pair, much as in *ariadne*, but the wings much suffused with black scales near their bases; under side of hind wings pale greenish yellow, not ochreous as in *keewaydin*, but without the grayish appearance of *ariadne*. Finally, the investigations of Verity, Barnes and McDunnough have shown that the original *eurytheme* of Boisduval was orange-flushed, and was essentially identical with *ariadne*. Boisduval was so impressed by the differences between this and the rich orange form that he called the latter a separate species, *amphidusa*. Both names were given in 1852, on the same page, but all agree in now employing *E. eurytheme* as the name of the collective species.

We may now recapitulate by saying that there is a yellow species in the East and an orange species or race in the West. Both produce white females, but never white males. The yellow species never gives rise to orange specimens, but the orange one produces yellow ones, not always easily separated from the Eastern *E. philodice*. But over a large range, from the Mississippi to the Pacific, are found orange-flushed specimens, closely simulating, at least, the hybrids raised by Gerould. In addition, there

is seasonal variation, with spring forms of smaller size, not genetically differing from the others. In addition to all this, it is probable that by collecting large series in many localities, at different seasons of the year, it would be possible to elucidate a certain number of local races. Whether *intermedia* is such a race, or merely shows the direct effect of the mountain climate, is at present quite unknown.

The family Lycaenidae includes the Blues, Coppers and Hair-streaks, small butterflies usually with metallic colors. The "Blues" are not always blue, but are often brown in the female sex. The under side usually has small dark spots on a pale gray ground. In a few species the wings have orange submarginal bands. *Lycaena heteronea*, blue in the male and blackish brown in the female, has markings on the under side like those of the "Coppers," to which group it is actually transferred in the latest Check-list. It is not uncommon in the mountains near Boulder. The Coppers (*Chrysophanus* and allies) are usually brilliant coppery red above, with some small dark spots. In some cases they are strongly suffused with black. The Hair-streaks (*Thecla* and allies) are of various colors, but mostly have one or more short slender tails on the hind wings. Our most interesting species is *Callophrys sheridani* Edwards. Above it is dark grayish brown, but beneath a beautiful shade of green, with a white line crossing each wing. It is considered one of the rarest of butterflies, but Sievert A. Rohwer took it at Boulder in April, and it has been taken by Professor Gillette of the Agricultural College. The larva remains unknown; it will probably be found on wild raspberry or a related plant. Allied to *C. sheridani*, and more common, is *C. dumetorum* Boisduval, in which the green under side is not crossed by white stripes.

The Skippers or Hesperiidae, very numerous in Colorado, are usually thick-bodied, like moths. The antennae have the tip of the club more or less distinctly pointed and bent. That these are more primitive than the other butterflies is shown by the venation of the fore wings, all the veins being present and separate. The larvae have the head and body separated by a distinct neck, absent in other butterfly caterpillars. We have no less than 25 genera represented in Colorado. The ones most likely to attract attention are the very abundant little Checkered Skipper, *Pyrgus*

tessellatus Scudder, and the much larger Silver-spotted Skipper, *Epargyreus tityrus* Fabricius. The latter will readily be known by its long front wings, and the splendid silver-white markings on the under side of the hind wings. Although it is common with us, it is a species of tropical affinities, ranging south to Central America. The larva feeds on leguminous plants. Very recently (1924) B. C. S. Warren has described a new Skipper, *Hesperia freija*, which is found at 13,000 feet altitude in Colorado, and ranges to Labrador and northern Europe.

Two other families of butterflies, the Libytheidae and Rhiodinidae, have been found in Colorado, but the single representative of the first, and the two of the second, are not commonly observed. *Libythea* has the straight palpi greatly extended, resembling a snout. The larva feeds on hackberry (*Celtis*). In former times the Libytheidae were probably more abundant, as two species have been found fossil at Florissant.

Chapter 11

MOTHS

The moths, technically known as Heterocerous Lepidoptera, are far more numerous than the butterflies. A list published in 1917 gives 7834 species in America north of Mexico. Formerly, it was customary to divide them into the larger moths, Macrolepidoptera, and the smaller ones, Microlepidoptera. This arrangement proved quite unscientific, since some very large moths are much more closely related to the little ones than they are to the forms with which we used to associate them. The most primitive moths are so similar to caddis-flies that Comstock formerly proposed to associate them with Trichoptera. In the course of evolution the number of veins in the wings has been reduced, and many other modifications and specializations have occurred. In the large silk-moths (Saturniidae) the mouth parts are reduced to mere vestiges; all the feeding is done in the caterpillar state. In the plume moths (Pterophoridae) the wings are split into plume-like divisions. A still more extreme case is that of the many-plumed *Orneodes*, a small moth with each wing divided into six plumes. It is common in Colorado, and may often be found in houses. Our species has been called *O. montana*, but is said to be identical with the European *O. huebneri*. If so, it is a member of the circumpolar fauna, for its wide distribution in all sorts of out-of-the-way places in the west makes it improbable that it has been introduced by man. The clear-winged moths (Ægeriidae) have the wings partly transparent, and on this account as well as their banded bodies, closely resemble wasps; the larvae burrow in the stems and crowns of plants, and sometimes do a great deal of damage. Not all clear-winged moths are Ægeriidae, however. The larger robust moths of the genus *Haemorrhagia*, looking more like bumble bees than wasps, belong to the group of sphinx moths (Sphingidae), and in spite of the clear wings have no affinity with Ægeriidae whatever. Some of the early writers did not appreciate this, hardly believing that nature could attain similar results quite independently; or, being without the conception of evolution, merely wishing to make a classification to facilitate recognition.

The Sphinx moths of Colorado include several very handsome species of large size. Perhaps the most beautiful are the two species of *Smerinthus*, known by the large eye-like spots on the pink-flushed hind wings. The upper wings are variegated with brown and gray, and when the moths are at rest, and the hind wings concealed, they look very much like withered leaves. In the larger of the two, *S. cerisyi* of Kirby, the black areas on the hind wings are ornamented with pale bluish rings. In the smaller, *S. jamaicensis*, these rings are represented by a pair of bluish spots. The name of the latter insect is unfortunate; the English entomologist Drury thought that his specimen came from the Island of Jamaica, where the species is never found. The name once given cannot be altered, even though founded on a mistake. The form of *S. jamaicensis* we have in Colorado differs from that usual in the Eastern States by having a very distinct Y-like (or gamma-like) mark on each anterior wing. It has been named *S. jamaicensis gamma*. The type specimen on which this race was named (now in the U. S. National Museum) was found sitting on the knob of the door of Dr. Ramaley's office, in the Hale Building of the University of Colorado. A related moth, but the hind wings without pink, and a single pale bluish spot on the black patch, is *Calasymbolus myops*. Here again the western form is distinct, and has been named *C. myops occidentalis* by B. P. Clark. It is paler than the typical race. A very large species, with a wing expanse of about four and three-quarters inches, and a very thick body, is *Pachysphinx modesta*. The hind wings are variably pink, but there is only a dark crescentic mark instead of an ocellus. Tha larva feeds on cottonwood trees. Our paler western form is called *P. modesta occidentalis*, but the insect is variable, and Colorado specimens are not usually as pale as the figure in Holland's Moth Book. Our commonest Sphinx moth, to be seen hovering over flowers during the summer months, is the white-lined Sphinx, *Celerio lineata*. The long pointed front wings have an oblique light bar crossed by fine white lines, and the hind wings are pink with black basal and marginal bands. The great tobacco or tomato moths, with mottled wings and yellow spots on each side of the abdomen, belong to two species. *Protoparce quinquemaculata* has the hind wings with a zigzag black line on a light ground; in *P. sexta* the hind wings are dark, crossed by

three light bands, the innermost short. There is a third, much rarer, species found as a larva on tomato. The hind wings are crossed by two white stripes, and the abdominal spots are creamy white, not yellow. This is *Mesosphinx separatus*, the genus distinguished from the related *Sphinx* principally by the characters of the larva and pupa.

Rivalling the Sphinx moths in size and beauty are the Saturniidae, or large silk moths. In the foothills and mountains of Colorado, a common species is *Samia gloveri*, known by the plum-colored inner half of the wings. The large light green larva has conspicuous red or yellow prominences; it is especially found on choke-cherry. In the Eastern States, this species is represented by the well-known Cecropia moth, which has brick-red marks on a dark brownish-gray ground, and lively red thorax with a white collar. This species (*Samia cecropia*) extends to the eastern plains of Colorado, and the larvae were reported by Henry Weeth to be very destructive at Peetz. Our other very large silk moth is the *Telea polyphemus*, common east and west. It is warm reddish, or sometimes (variety *olivacea*) olivaceous, the wings with translucent patches, that on the hind wings on a large black patch, the center suffused with blue. The larva of *Telea* is easily known from that of *Samia* by the reddish-chestnut head. A much smaller though good-sized insect is the Io moth (*Automeris io coloradensis*), our form being racially distinct from that of the Eastern States. The hind wings have a large round black patch, in the center of which is a white mark, surrounded by a purplish suffusion. Under a lens, from one angle we see merely white scales on a black ground, surrounding the white mark, but from a different direction the surface appears beautifully purple. The scales of this part of the wing are short and broad, but the black ring is overlaid with long strap-shaped scales. The females have an expanse of about three and one-half inches, the males about two and three-quarter inches; in the former the front wings are deep reddish, more or less plum color, in the latter they are yellow. Thus the sexes look like quite different species. The green larva is covered with clusters of spines, which have stinging properties. It may be found on various woody plants. A very pale-colored member of this family, *Hemileuca oliviae*, comes from a larva which feeds on grass. It has been very destructive to the

cattle-ranges in New Mexico, and specimens are sometimes found in southern Colorado. There is another Saturniid which deserves mention, because its generic name is derived from that of the State. *Coloradia pandora* of Blake has the broad upper wings grayish, with a black discal spot, the lower wings much paler. The larva feeds on pine. The moth is occasionally found in Boulder, having been taken by G. Hite and Miss A. O. Todd.

The family Arctiidae derives the name from the Greek word meaning a bear, the very hairy caterpillars being called "woolly bears." We have numerous species, some of them beautifully colored and marked. The salt-marsh moth, *Estigmene acraea*, is very common. It has the greater part of the abdomen yellow, with a row of black spots down the middle. In the female the wings are white with small black spots, in the male the fore wings are white, the hind wings yellow. *Diacrisia virginica* of Fabricius is a smaller white moth, with hardly any dark markings. In 1910 the larvae were found on mint (*Mentha*) in Boulder. They have two forms, appearing different, but they proved to belong to one species by Mrs. Cockerell, who raised both from one batch of eggs. The commoner form of caterpillar has the head light yellow, the back blackish (marbled with dilute black on a gray ground), sides with a broad dull yellow stripe, under surface lead-gray; thoracic legs pale yellowish; tubercles with large spreading bunches of light ferruginous hair, with a good many black hairs intermixed. In the other form the head is dark reddish, the mouth yellow; hair of body black anteriorly and posteriorly, but on middle segments partly ferruginous; yellow lateral band reduced; thoracic legs yellow. The general appearance is very dark, in strong contrast to the other form of larva. These differences are interesting, as showing that an insect may have two forms, very distinct in the larva, but not at all differing in the adult. In other cases the larvae are alike, but the adults show great variation. *Isia isabella* of Abbot and Smith is another common moth. It is clay yellow, sometimes slightly flushed with pinkish. There is a row of black spots down the middle of the abdomen. The larvae are often common on the campus of the University of Colorado and are easily recognized by the fact that they are densely covered with long hair, which is reddish brown in the middle of the body, but black at each end.

The family Agaristidae is represented by few species in North America, but the Eight-spotted Forester (*Alypia octomaculata* Fabricius) is very common, the caterpillars feeding on Virginia Creeper. The moth is a rather small, stout bodied insect, with black wings on which are large light spots, two yellow ones on each fore wing, and two white ones on each hind wing. It may often be seen in gardens.

The Noctuidae constitute an immense assemblage of moths, several of which are familiar as cutworms in the larva stage. In general, these moths are dull colored and unattractive, but some are exceedingly beautiful. The *Rhodopipsa masoni* of Smith is found resting on flower heads of *Gaillardia aristata*, with which its red and orange colors exactly harmonize. It was discovered by Mr. J. Mason,* formerly of Denver, through the picking of a *Gaillardia* flower on which a moth happened to be resting. Another very beautiful moth is *Rhodophora gaurae*, the larva of which feeds on *Gaura*, a plant of the Evening-primrose family. The upper wings are white flushed with delicate pink, and with an oblique bar of deep pink. Other handsome noctuids are the large moths of the genus *Catocala*, which especially frequent the trunks of cottonwood trees. When at rest on the trunks of the trees, they are very hard to see, the gray mottled wings being just like the bark. But when they fly, we see the under wings, banded with bright red and black. Several species have been found at Boulder, namely *C. hermia* Hy. Edwards, *C. luciana* Hy. Edwards, *C. verecunda* Hulst, *C. aspasia* Strecker, and *C. aspasia* var. *augusta* Hy. Edwards.

In September 1914 great numbers of the Cotton-worm moth (*Alabama argillacea*) appeared about the lights in Boulder. About the same time they were observed at St. Paul, Minnesota. The moth breeds in the cotton fields of the south, and occasionally migrates in great swarms. Such migrating moths, coming north, of course perish, leaving no offspring. The moth has the upper wings warm light reddish brown, with a dark spot on the base of which is a white dot. This must not be confused with the Boll-worm moth (*Heliothis obsoleta*) the wings of which are pale ochreous varying to light olivaceous, with a dark spot and faint

*Mr. Mason's very fine collection of Lepidoptera is preserved in the Colorado Museum in City Park, Denver.

dusky band. This insect flies by day, and is exceedingly abundant in Colorado in late summer. Although it is a native of the State, it is probable that most of the moths seen late in the season come from the south. The larva not only injures cotton, but is very fond of the ears of sweet corn, and of tomatoes.

The Lasiocampidae are represented by *Malacosoma fragilis*, the velvety larvae of which make web-like structures in trees, and are often very destructive, especially in groves of aspens. They are known as Tent-caterpillars.

The large group of Geometridae (the word meaning earth-measurers) consists of mostly broad-winged slender bodied moths, the larvae of which are loopers. A monograph of these insects, by A. S. Packard, was published in 1876 as one of the reports of Hayden's Survey of the Territories. We cannot discuss the various species here, but it is worth while to mention the *Ennomos ochreatus* of Hulst, which appears in the fall, and looks just like the yellow fallen leaves among which it may frequently be found. One of our most beautiful and striking species is *Melemaea magdalena* of Hulst, which I found at Grand Lake in September. It seems to be excessively rare.

The Pyralidae are moths of medium or small size, and slender build. The species of *Loxostege* are known as web-worms in the larva state, and are often very destructive. The sugar-beet Web-worm (*Loxostege sticticalis*) is well described by Asa C. Maxson,* who says: "The sugar-beet webworm is one of the most destructive leaf-eating insects attacking the sugar-beet. Like many of our most injurious insect pests, it was introduced into this country from the Eastern Hemisphere, appearing first on the Pacific coast." Some authors believe, however, that it was native in the west, having spread by natural means from Asia. Mr. Maxson states that in 1915 this insect caused a loss of not less than 26,450 tons of beets. Over 16,000 acres were sprayed with Paris green, 84,000 pounds of this substance being used. But for this, the loss would have been very much greater.

There are many families of small moths, some of them of unusual interest. The beautiful white *Tegeticula alba* (or *T. yuccasella*) is the means of fertilizing the Yucca plant. The

*Principal Insect Enemies of the Sugar Beet (1920); a very valuable book issued by the Great Western Sugar Company.

larvae live in the *Yucca* pod, boring through the flat seeds, so that from being like dollars, they come to look like doughnuts, on a very small scale. The Codling-moth (*Carpocapsa pomonella*), so destructive to apples, is a European species accidentally introduced into America. The pink larva bores into the fruit.

Chapter 12

CRUSTACEA

The Crustacea are divided into a number of orders, most of which are quite easily recognized. The Decapoda, comprising the crabs, lobsters, crayfish, etc., are well known to all. Our representatives are the crayfish, belonging to the family Astacidae or Potamobiidae. The word crayfish has a curious origin. The old German Krebis, for large Crustacea in general, has become krebs in modern German, and crab in English. But in France the name is applied to the common animal of the streams, and became modified to ecrevisse. This, finally reaching England, was converted into crayfish, which in America occasionally becomes crawdad. The typical genus of Crayfishes, *Astacus*, is found from Europe to the Pacific coast region of the United States. But in the Eastern United States, and west to the base of the Rocky Mountains, is a different genus called *Cambarus*, quite rich in species. This genus also occurs in Mexico, and even has a species in Cuba. *Cambarus diogenes* of Girard, the name suggestive of its habits, is very common in Boulder. On it was discovered a remarkable parasitic worm, named *Cambarincola macrodonta* by Ellis. Another crayfish, *Cambarus virilis* of Hagen, was the host of the worm *Cambarincola vitrea* of Ellis in the Arikaree River, near Beecher's Island. It is singular that these crayfish worms (Branchiobdellidae), though referable to several genera and numerous species, do not restrict themselves to particular species or even subgenera of *Cambarus*. One species of worm has actually been found on twelve kinds of crayfish. The *Cambarincola macrodonta* is common in Eastern Colorado on *Cambarus diogenes*, but if we go south to Las Vegas, New Mexico, we find an entirely different crayfish, belonging to another group of the genus, one which has Mexican relationships. Naturally we should expect to find here a different worm, but according to Dr. Ellis it is the very same *C. macrodonta*.*

The Amphipoda are suggestive of small shrimps, with com-

*A good account of the Colorado crayfishes, by E. T. Engle, appears in Bulletin of the Bureau of Fisheries, XLII (1926). It is regrettable that Engle has published the records of Dr. Ellis in such a manner that no one can tell who collected or identified the specimens. In the case of *C. simulans* from Kit Carson County we are informed that Faxon made the determination, but no credit is given to Ellis for adding this species to the fauna of Colorado.

pressed many-segmented body. They live in salt and fresh water, and in Japan I observed a terrestrial species. Ours are found in mountain lakes, the *Gammarus limnaeus* of S. I. Smith being common. Miss Rathbun informs me that two other species of Amphipoda, *Dikerogammarus fasciatus* and *Eucrangonyx gracilis*, are represented by Colorado specimens in the U. S. National Museum.

The Isopoda are the so-called wood-lice and pill-bugs, terrestrial animals common under stones. *Armadillidium vulgare*, the European pill-bug, was abundant in a greenhouse at Boulder, of course introduced. When alarmed, it curls up in a ball, hence the generic name, meaning like an armadillo. The wood lice found out-of-doors also appear to be species introduced from Europe.

The Ostracoda, living in fresh waters in great abundance, are small creatures enclosed in a carapace which has the form of a bivalve shell. It would be easy to mistake them for small molluscs. As the little shells are easily preserved, they often occur as fossils, and one species (*Cypris florissantensis*) is common in the Miocene shales at Florissant. Professor A. E. Beardsley of Greeley has long been studying the Colorado Ostracoda, and tells me that he has more species from our State than are at present recorded from the whole United States.

The Copepoda are very small fresh water Crustacea, without carapace, and without paired eyes. It is the single median eye which has caused the name *Cyclops* to be given to the genus containing the commonest forms. There are two pairs of antennae, and the females carry the eggs in a pair of sacs, one on each side of the abdomen. The largest Colorado genus is *Diaptomus* of Westwood, with thirteen species, three of which were originally described from Colorado. Some of them are beautifully colored when alive. Some very peculiar Copepoda are parasitic on fishes, and certain of them are quite large. The Order Branchiura includes the genus *Argulus*, a species of which (*A. trilineatus* Wilson) was found on a gold-fish in Boulder by Mr. Guy Mason. It has round adhesive discs on the under side of the body, and the tail is deeply notched.

The Cladocera or water fleas are something like the Ostracoda, but with a clearly visible external head and distinct paired

eyes. The large branched antennae are used in swimming. Thirty-four Colorado species are known.

The Conchostraca have a comparatively large bivalved shell, one of our species (*Estheria morsei* of Packard) being 10 to 12 mm. long. The genus *Estheria*, with 18 to 22 concentric lines of growth on the shell, is easily recognized. It is often abundant as a fossil; I found it in quantity in rocks of Rhaetic age near Mendoza, Argentina. The species of *Estheria* may be found in pools on the plains, as at La Junta, Fort Collins and Greeley. *Eulimnadia texana* of Packard, with only five lines of growth on the shell, was taken at La Junta.

The Notostraca, relatively large animals with a shield-like carapace, and a many-segmented abdomen projecting behind, also occur in isolated pools. At the end of the abdomen are two slender tails. The commonest genus is *Apus*, but we also have a genus *Lepidurus*, recognized by the paddle-like process at the end of the abdomen, between the caudal filaments. The genus *Apus* (*Apus obtusus* James, 1823) was first observed in Colorado by Long's Expedition in rain water puddles near the Platte River. It appears to be the same species as that much later called *A. longicaudatus* by LeConte, based on specimens from near Long's Peak. Mr. H. C. Markman found it abundant in a road-side pool at Montclair, near Denver. The sporadic occurrence of *Apus* has frequently been commented upon. It will suddenly appear in abundance in rain-pools, and may not be seen again for a long while. In England, *Apus cancriformis* was formerly found in several places, but for over forty years none were seen in the British Isles. Then, in 1907, it reappeared, specimens being found in the south of Scotland. How did they get there? It is known that the eggs are not killed by drying, and they may readily be carried in mud on the feet of wading birds, which fly for long distances on migration. Thus it is possible for *Apus* to spread, and appear where it was long unknown. Also, the eggs apparently survive in the mud of dried-up pools for a long time, permitting the development of the adults when circumstances are favorable.

The Anostraca or fairy shrimps are sometimes over an inch long, slender-bodied, without any carapace. The segmentation is very distinct. These also occupy temporary pools, often in

company with *Apus*. When alive, they are beautiful objects. Our species belong to the genera *Branchinecta*, *Thamnocephalus* and *Streptocephalus*. The *Thamnocephalus platyurus* of Packard, found at Montclair and La Junta, is a most remarkable form. The head of the male has a trunk-like process, which is profusely branched in the manner of a tree. The posterior abdominal segments are united with the terminal piece or telson to form a fin, which is deeply notched apically, and has setose margins. In the other two genera the posterior abdominal segments are not thus modified, and *Branchinecta* is quite without a frontal process in the male. There are three Colorado species of *Branchinecta*, of which *B. coloradensis* of Packard occurs in the mountains, to over 11,000 feet. altitude, while the other two come from the plains or foothills. *B. packardi* of Pearse is only known from Colorado, the type locality being La Junta. In a similar manner, *Streptocephalus* has a species (*S. coloradensis* of Dodds) in the mountains, and another (*S. texanus* of Packard) on the plains. However, *S. coloradensis* is not known from higher up than Eldora and Ward, and does also occur on the plains, at Fort Collins.

All the above Crustacea, excepting Decapoda, Amphipoda and Isopoda, are known collectively as subclass Entomostraca. Those who wish to identify our species (excepting the Ostracoda) will find a useful guide in "A Key to the Entomostraca of Colorado," by G. S. Dodds, University of Colorado Studies, XI (1915), No. 4. The groups of Crustacea not discussed by Dodds are briefly treated in University of Colorado Studies, IX (1912), pp. 47-51. In 1917 (Proc. U. S. National Museum, vol. 54) Dodds published a very interesting discussion of the altitudinal distribution of Entomostraca in Colorado. He shows that nineteen of our species also occur in the Swiss Alps, and fifteen in Northern Sweden.* The highest altitude in Colorado is reached by *Branchinecta coloradensis;* only this and *Diaptomus shoshone* go above 12,000 feet. Eighteen species go above 11,000 feet. The genus *Diaptomus* is sharply divided ecologically into a group of five species which occur high in the mountains, and six which occur only below 6,000 feet; but there are two others which

*Nine of our species also occur in the Panama Canal Zone, as may be gathered from a list recently (1926) published by Dodds. The average size of the species in the Colorado Rockies is considerably greater than in the Panama region.

range from about 5,300 to about 11,000 feet. All these species are peculiar to North America, whereas only one of our *Cyclops* is confined to this continent. The species of *Cyclops* are conservative, and have spread over the world with little change. *Diaptomus*, on the other hand, is plastic, giving rise to new species in many localities, so that no species is world-wide in its distribution.

MILLIPEDES (DIPLOPODA)

The Millipedes are cylindrical or more or less flattened, with seven antennal joints. The body segments mostly bear two pairs of legs, whence the name Diplopoda. They move slowly, and curl up when alarmed. The group is a very ancient one, and is widely spread over the earth. In Mexico some of the millipedes are of great size, but our Colorado forms are all relatively small. The common cylindrical shiny ones belong to the genus *Parajulus*; the *P. venustus* of Wood was found at Tolland and in Gregory Canyon near Boulder, while *P. garius* of Chamberlin comes from Tolland. *Conotyla coloradensis* of Chamberlin was described from specimens taken at Salina, but in 1911 I found it at Tolland. There is a very widespread species, *Orthomorpha gracilis* of Koch, which is common in greenhouses in Boulder. Mrs. Cockerell found it out of doors in Guatemala City, Guatemala. Dr. R. V. Chamberlin writes that it was first described from greenhouses in Europe, its original home was probably the Asiatic or East Indian region. It is now almost cosmopolitan, being carried about with plants. Dr. Chamberlin found it in the open at Birmingham, Alabama, and it is evidently well-established in the warmer parts of North America. A North African millipede, *Diploiulus africanus* of Brolemann, was found in hothouses at Colorado Springs, while *Polydesmus sontus* of Chamberlin was observed in a Denver greenhouse.

CENTIPEDES (CHILOPODA)

Soft, flattened, usually active animals, with only one pair of legs to a segment. The first pair of legs is modified into poison claws, the poison being secreted by special glands, and ejected through a passage opening near the tip of the claw. The very large and terrifying centipede, as long as one's finger, is *Scolo-*

pendra heros of Girard. It is rather common near the eastern base of the mountains, as in the vicinity of Boulder. It was taken at Rocky Ford by Burt E. Warren. In houses (on one occasion in the main building of the University of Colorado), running about the walls in search of flies, may occasionally be found a singular centipede with extremely long legs. This is the *Scutigera forceps* of Rafinesque, not really a native of Colorado, but introduced from the south. Under stones the reddish-brown Lithobiidae are very abundant, and the long thread-like Geophilidae are sometimes found. There are several native Lithobiidae, which have been discussed or described by Dr. Chamberlin. In his latest paper (1925), he describes a new species *Neolithobius suprenans*, which was first collected in Colorado by members of the Hayden Survey in 1873, but has had to wait 52 years to be made known. *Nadabius coloradensis* is one of our common forms; it is 12 to 16 mm. long when adult, and has the angles of none of the dorsal plates produced. *Pokabius pungonius* was found at Marshall, and has never been detected anywhere else. Some years ago I found the European *Lithobius forficatus* of Linnaeus (certified as such by Chamberlin) in Boulder. It has of course been brought in accidentally by human means. In Europe it is extremely common; I collected it at Southwater, Sussex, England, and Wangen, Baden.

There is still much to be done on our millipedes and centipedes, and no doubt many species await discovery. There has never been a special student of these groups in Colorado.

TICKS AND MITES (ACARINA)

Ticks are really gigantic mites, mostly living on and at the expense of warm-blooded vertebrates. The species are not very numerous, but they make up for this in the abundance of individuals. The only kind which is particularly noticeable in Colorado is the common wood-tick, which is a source of annoyance to camping parties and strollers in the woods during the earlier part of the summer. This is the tick which has long been known in Montana as the transmitter of the organism causing Rocky Mountain spotted fever, a very deadly disease. In recent years spotted fever has spread southward into Wyoming and Colorado,

but appears to be less virulent in these States. The chances of acquiring the disease are small, yet no one should needlessly take the risk, and in any case it is highly undesirable to be bitten by a tick. If those who have been in the woods will carefully examine their clothing and bodies on returning home at night they can avoid tick bites. The ticks wander about and do not bite until some hours after locating on the person.

The scientific name of the spotted fever tick has caused a great deal of discussion, and was finally referred to the International Commission on Zoological Nomenclature. The findings of the Commission, discussed in fourteen pages of print, were not very satisfactory, but actually the case seems simple. Dr. N. Banks first described the animal as *Dermacentor venustus*, but under this name he confused two species. Dr. C. W. Stiles in 1908 proposed the name *Dermacentor andersoni* for the spotted fever tick, leaving the name *D. venustus* for a species found on sheep in Texas, which had been included by Banks. Consequently *D. andersoni* is the name of the tick with which we are concerned.

Trees and shrubs are frequently observed to be apparently diseased, the leaves being blotched or curled, or the ends of the branches distorted. Many years ago it was supposed that these effects were produced by microscopic fungi, but we now know that most of them can be attributed to excessively small elongated mites, peculiar for having only four legs. The mites set up irritation which results in the formation of galls. They constitute a family Eriophyidae, which of late years has been intensively studied in Europe, with the result of discovering a vast number of species. No doubt similar discoveries await any student in Colorado who will seriously devote himself to this subject. One of our commonest forms is that which produces the bright red blotches on leaves of mountain maple. Another makes galls on willow. A third (*Eriophyes rhoinus*) produces gall masses consisting of modified branches and multitudes of small, distorted leaves, on the wild sumach.

Bright scarlet mites of the genus *Trombidium* are often observed walking over the ground. They are oblong, and have a velvety appearance. Their young stages are parasitic on grasshoppers and other insects. Another genus of mites, *Trichotarsus*, is parasitic on wild bees. *Bryobia pratensis* of Garman is a mite

which lives on vegetation, and occasionally enters houses in vast numbers, causing alarm. Species of *Tetranychus* (so-called red spider) occur on the leaves of orchard trees and on greenhouse plants, spinning a fine web over the leaf surfaces. They are quite injurious to vegetation. Ewing described a new species, *T. weldoni*, found in Colorado on apple, prune and cottonwood trees. The scab of sheep is caused by a mite (*Psoroptes*) and there are various other mites infesting domestic animals, fowls, and even man. Recently it has been shown that a serious disease of honey bees is due to a mite living in the breathing tubes, but this has fortunately not reached Colorado.

SPIDERS (ARANEIDA)

The true spiders have a cephalothorax, that is head and thorax all in one piece. The abdomen in all our species shows no segmentation, the eyes are numerous, and the legs number eight. The Colorado spiders are much too numerous to describe or even enumerate, but a few conspicuous types may be mentioned. The large fat-bodied species which spin circular webs about buildings belong to the genus *Epeira*. It is richly represented in Colorado with fifteen species. Related to it, but more or less silvery, with the more elongate abdomen transversely barred, are our two species of *Argiope*, both of which have been found on the University of Colorado campus. The Crab-spiders, squatting down, with the legs at the side after the fashion of a crab, constitute the family Thomisidae. The most interesting one is *Misumena vatia*, which sits on flowers, catching the bees and other visitors as they come. It varies from white to deep yellow, and usually matches the flower in color; but on pink flowers yellow spiders sit and appear to do good business. Can it be that some of the insects do not distinguish between pink and yellow? The jumping spiders, or Attidae, are very characteristic. They do not spin webs, but actively hunt their prey. We have many species, the most common belonging to the genus *Phidippus*, one member of which is bright red above, and extraordinarily resembles a wingless wasp of the family Mutillidae. The wasp stings viciously; can it be that the spider is protected from its enemies by the resemblance? The Lycosidae, or Wolf-spiders, are some of them

quite large, but none brightly colored. A common species is *Lycosa carolinensis*, the female reaching a length of over an inch, mouse-color above, largely black beneath. In the breeding season the egg-bag is carried, attached beneath the abdomen. About the University campus at Boulder, and elsewhere, one may find under rocks a fat, round-bodied, jet-black spider, with a little bright red spot at the tail end. This is *Lathrodectus mactans* of Fabricius, extending from the temperate zone to the tropics, and famous for its poisonous bite. There is a very interesting small spider (*Phrurolithus*) which lives under rocks with ants of the genus *Crematogaster*. In the Eastern States both ants and spiders are black, but at Boulder the ant is a different form, having a red thorax, so the spiders possess a red cephalothorax to correspond.

HARVEST-SPIDERS (PHALANGIDA)

These animals, sometimes called daddy-long-legs, have extremely long legs, and may be mistaken for true spiders. They are, however, easily separated by the form of the body, the cephalothorax not being separated from the abdomen by any waist-line or constriction. Thus they have the outline of Humpty-Dumpty. We have several species, one of the most curious being a small red one (*Sclerobunus robustus* of Packard), found under stones in the mountains.

PSEUDOSCORPIONS (PSEUDOSCORPIONIDA)

Like very minute scorpions, but without any tail. They may be found under rocks and beneath the bark of trees.

SCORPIONS (SCORPIONIDA)

Easily known by the long tail, at the end of which is the sting. The group is one of enormous antiquity, older than any known insects.

SOLPUGIDS (SOLPUGIDA)

Peculiar pale-colored soft animals, resembling spiders, but the elongated abdomen is distinctly segmented. They are

especially characteristic of desert regions. *Eremobates pallipes* of Say, a species about 13 mm. long, occurs in Colorado.

ECHINODERMATA

This large group of marine animals, including sea-urchins, star-fish, crinoids, etc., found in Colorado only in the fossil state, recalling the time when the ocean covered large parts of what is now Colorado. *Miocidaris cannoni* of Jackson (1912) is an interesting fossil sea-urchin found in the Lower Carboniferous near Denver. Its specific name commemorates the well-known teacher of East High School, Denver.

Chapter 13

WORMS

The name Vermes was formerly used in a very broad sense, to include the many kinds of animals commonly called worms, though not the caterpillars or larvae of moths and butterflies. The name itself, the plural form of the Latin Vermis, a worm, is hardly different from the English term. It could not begin with W in Latin, because that letter does not exist in the language. Zoologists who studied the anatomy of worms became aware of the fact that there are several great groups or Phyla, radically differing in their structure. Thus there is the group of Platyhelminthes, the Flat-worms, the formidable scientific term meaning exactly that in Greek. Another group consists of Roundworms, Nemathelminthes, sometimes called simply Nemas. Then we have the Rotifers, belonging to the Trochelminthes, minute creatures at first glance looking more like Protozoa than worms. Finally the Annelida, or segmented worms, include earthworms and leeches. They are regarded as the "highest" of all, approaching in some respects the arthropod type.

The worms of Colorado include those which live in fresh water or damp earth, or are parasitic. Undoubtedly we have many species, but as yet they have only been partially studied. The scientific description of worms involves a more or less elaborate technique, and in many cases it is necessary to cut specimens into great numbers of thin sections, which must be stained and examined under a high power of the microscope. Thus no one can make a good Helminthologist (this means in Greek, student of worms) unless he has a large amount of time, a like amount of patience, and a good deal of manual skill. The uninformed public is likely to wonder why any one should go to all this trouble, but the scientific student has no such doubts. Not only is he interested in working out nature's puzzles, as such, but he is well aware that the fate of peoples may hang on such results as he attains. To cite only one case, knowledge of the hookworm and its life history means the rejuvenation of the Southern States, which have long suffered from the nameless malady which sapped the energy of thousands, so that their name was a by-word to those who did not understand. Again, we may recall how sheep

perished from the liver-fluke, and no help seemed available, until a student of worms discovered the life story of the parasite, and how it abode in a common fresh water snail.

FLAT-WORMS

The free-living forms, known as Planarians, are found in fresh water and on the land. No terrestrial species have been found in Colorado, and presumably none exist, the climate being too dry. A dark colored aquatic form, looking like a small flat slug, is not rare in mountain springs, but it has not been identified.* A very minute animal, resembling some of the ciliate Protozoa, has been observed at Boulder. It belongs to the Order Rhabdocoelida, but its exact classification is unknown. The parasitic flat-worms include the Trematodes or flukes, and the Cestodes or tape-worms, both of considerable economic importance. The fluke *Fasciola magna* of Bassi was found at Colorado Springs, infesting the liver of cattle. Hassall in 1891 regarded the specimens as representing a new species (*F. carnosa*), but this apparently was a mistake. Ward (1918) places the species in a new genus, which he calls *Fascioloides*, distinguished superficially by the broad form, with no snout-like anterior projection. This fluke was originally discovered in the wapiti (our so-called elk) in a zoological garden in Europe.

Cestodes or tape-worms are as frequent in Colorado as elsewhere. Hall** gives a long list of records, the various species infesting mammals (including man), birds, and even amphibians and fishes. Thus *Davainea salmoni* of Stiles was found to be very common in the intestine of cottontail rabbits in Elbert and El Paso Counties; it is a worm about 88 mm. long and three wide. A different tape-worm, *Cittotaenia mosaica* of Hall, was described in 1908 from a cottontail collected near Seven Lakes. It is easily separated from the other by the fact that the scolex ("head") is without hooks. Hall in 1912 reported that the gid parasite infesting the brain of sheep had no foothold in Colorado, though established in northern Montana. This animal, *Coenurus multiceps* of Leske,*** lives as an adult worm in the dog, and it is the

*In 1922 specimens of *Planaria maculata* and *P. dorotocephala* were liberated by Miss Dorothy Young in the pond on the University of Colorado campus.

**The Parasite Fauna of Colorado. Colorado College Publication, Science Series, Vol. XII, No. 10 (1912).

***Concerning the name, see Nature, March 9, 1922, p. 310.

immature or bladderworm stage which is so destructive to sheep. The whole subject of tape-worms in the Rocky Mountain Region is in a beginning stage, and offers a fine field for research.

ROUND WORMS

Dr. Maurice C. Hall, in the work cited above, records very numerous species of parasitic Nematodes, the majority inhabiting the alimentary canal of mammals. The free-living forms, existing in the water and soil, have been observed but hardly studied. In 1916 Hall* published a very important revision of the nematode parasites of rodents. Mr. E. R. Warren of Colorado Springs saved for him alcoholic material obtained during his researches on Colorado mammals, and it is mainly due to him that the following were described and recorded from our State: *Trichuris fossor* Hall (new) in *Thomomys fossor; Heteroxynema cucullatum* Hall (new genus and species) in *Eutamias operarius*; *Oxyuris obvelata* Rudolphi in *Neotoma mexicana fallax; O. tetraptera* Nitzsch in mice; *O. triradiata* Hall (new) in spermophiles; *Dermatoxys veligera* Rudolphi in rabbits; *Ransomus rodentorum* Hall (new genus and species) in *Thomomys fossor; Trichostrongylus delicatus* Hall (new) in Abert's squirrel, *Nematodirus neotoma* Hall (new) in *Neotoma; Citellinema bifurcatum* Hall (new) in *Citellus elegans; Warrenius quadrivittati* Hall (new genus and species) in *Eutamias quadrivittatus; Heligmosomum vexillatum* Hall (new) in *Thomomys fossor; Rictularia coloradensis* Hall (new) in *Eutamias quadrivittatus; Protospirura muris* Gmelin in mice and rats. These names naturally mean little to anyone but a helminthologist, but they are given to show the abundance of these worms, and the excellent opportunities for discovery of new forms. The disease called trichinosis, due to the presence in the muscles of the worm *Trichinella spiralis* of Owen, has been observed in Boulder. Man gets it by eating insufficiently cooked pork, in which the cysts of the parasite may not rarely be found. With proper inspection of meat, and adequate cooking, this disease will be abolished.

Cobb in 1914 described a free-living freshwater nematode, *Ironus americanus*, from Deer Bottom in the Pike's Peak region.

*Proc. U. S. National Museum, vol. 50, pp. 1-258.

It is figured in Ward's "Fresh Water Biology," p. 486. In the same year another freshwater species, probably carnivorous, was described as *Tripyla lata*, from Alpine Lakes, Bald Mountain. Numerous other species will be found by any one who cares to hunt for them.

In addition to the nematoda, there are two other classes of round worms, much less numerous in species. The Gordiacea or hair-worms, parasitic in insects, are very degenerate creatures, the mouth absent and the intestine not functional in adults. The eggs are laid in water, and the young on hatching bore into the tissues of aquatic insect larvae, such as those of May-flies. Well grown hair-worms occur in the body cavity of terrestrial insects, such as crickets; but eventually the adult worm lives a free life in water, becoming sexually mature and producing a cord of eggs which may be several feet long. Full particulars of the species are given in Ward's book already cited. These hair-worms are common in Colorado, and here, as elsewhere, the legend is current that they arise from horse-hairs. The species we have found at Boulder has not been identified, but it is probably *Paragordius varius* of Leidy, which is known to exist in Kansas, Nebraska and California. The tail end of *P. varius* is trilobed in the female and bilobed in the male.

There is another peculiar group called Acanthocephala, the name meaning spiny-head. They have a spiny proboscis, with retractile hooks, by which they attach themselves to the intestines of their vertebrate hosts. There is no alimentary canal in any stage of development. Hall records *Echinorhynchus* in the intestines of the domestic pig in Colorado. According to Kaupp it was said to be common at Fort Collins.

ROTIFERA

The rotifers or wheel-animalcules are microscopic, living abundantly in fresh water. They look at first sight more like Protozoa than worms, but as they are more or less transparent it is possible to see their complicated anatomy while they are still alive. No careful study of the Colorado species has been made, and only a few have been recorded.* A fine red species of

*University of Colorado Studies, vol. VIII (1911) p. 248.

Callidina was found by Mr. E. Bethel in a small pool on South Boulder Peak. According to Harring's Synopsis* it would fall in the genus *Macrotrachela*, which includes species notable for their handsome appearance, as suggested by the specific names mirabilis, decora, formosa, etc., given to them. In the Proceedings of the U. S. National Museum, vol. 42, (1912) p. 181, will be found full directions for collecting rotifers and preparing them so that they are fit for study. It is thus possible for those who are not specialists to contribute the materials whereby our rotifer fauna may become known.

Those who are using the microscope to examine rotifers and other minute aquatic organisms will occasionally meet with very singular elongated creatures, appearing to have whiskers like a cat, a spiny or bristly body, and a bidentate tail. These are Gastrotricha, an isolated class without near relatives. They have been observed at Boulder, but the species was not determined. Most of the American species have been described from specimens collected by Stokes at Trenton, New Jersey, but other localities would doubtless be quite as prolific if proper search was made.

ANNELID WORMS

The annelid worms, with segmented body, consist in our fauna of the Oligochaeta or earthworms and their relatives, and Hirudinea or leeches. The first of these groups includes some animals which do not look at all like earthworms. One of these is *Aeolosoma*, a microscopic freshwater worm with minute orange spots. It is found occasionally at Boulder. Another family, known as Branchiobdellidae (wrongly called Discodrilidae), consists of peculiar small worms externally parasitic on crayfishes. The species *Cambarincola macrodonta* and *C. vitrea*, both described by Dr. M. M. Ellis, have been found in Colorado. The Enchytraeidae constitute a family of small annelid worms, found in fresh water or damp places, and very widely distributed over the earth. In 1917 Welch described *Mesenchytraeus altus*, collected near Corona, close to the edge of a small lake on the east side of Mt. Epworth. It occurred in moss and under old wood. When preserved in alcohol it was about 17 mm. long. The true earth-

*Syncpsis of the Rotatoria. Bull. 81, U. S. National Museum (1913).

worms, or Lumbricidae, appear not to have been native in Colorado, although they occur in most parts of the world. The old settlers say there were not any when they came, and Dr. Frank Smith, when he visited the State, found only introduced forms, which are now abundant. These belong to the genera *Helodrilus*, *Octolasium* and *Lumbricus*. Leeches or Hirudinea occur in our lakes and ponds, but have not been closely studied. At Canon City, Hall collected *Placobdella rugosa* of Verrill and *Erpobdella punctata* of Leidy. The latter is a large leech, not averse to sucking human blood. Many years ago Ingersoll reported two species of leeches from Saguache, and in 1874 Verrill recorded six Colorado species, his localities being in the region about Long's Peak. The *Clepsine pallida* of Verrill is the circumpolar *Glossiphonia complanata* of Linnaeus. It was found in Estes Park.

COELENTERATA

The class Hydrozoa (or Hydromedusae), abundant in the sea, is represented in Colorado by the freshwater *Hydra*, which is not uncommon. It is a small creature with a cylindrical body and long tentacles, and is attached at the base to some object. It can reproduce sexually or by budding. The green form is *Hydra viridis* of Linnaeus.

PORIFERA OR SPONGES

Common in the sea but some species are found in fresh water. *Ephydatia muelleri* of Lieberkuehn has been found at Tolland. It is cushion-like, rarely branched.

Chapter 14

PROTOZOA

The Protozoa are minute animals, for the study of which it is necessary to use a compound microscope. They are therefore hardly to be classed among the "common objects of the country side," at least from the standpoint of the casual observer. Yet it is interesting to contemplate a shady pool, or a mossy swamp, and realize that such places support a population of millions of minute creatures, which live, work, feed and reproduce, but do not necessarily die. They may die through accidents, we may swallow some of them in our drinking water; but there is no obligatory death, since reproduction is by division into two or more individuals. The two children are not merely derived from the parent, they *are* the parent, all of it, now consisting of two persons instead of one. We speak of the Protozoa as consisting of one cell, or vital unit, instead of millions as the case with ourselves. They are unicellular, we are multicellular. We also think of them as very primitive, and comparatively very simple. They are not, in fact, so simple as we might believe; some of them are very extraordinarily complex for such microscopical objects. Careful study reveals many remarkable features, and shows us that there are almost innumerable genera and species, differing by quite recognizable characters. In spite of all this diversity, there is a tendency to conservatism, which has kept many of the species practically unchanged for very long periods. How do we know this? Because when we investigate the freshwater Protozoa of remote countries, lakes in temperate regions, tropical islands, antarctic shores, the same species turn up over and over again. It must have taken immense periods for these little animals, originating somewhere on the earth, to spread so widely. Were they more plastic, more easily influenced by conditions, we might expect to see entirely different forms in diverse countries and climates, as is generally the case with the higher animals. *Clathrulina elegans*, having a spherical yellowish or brown shell on a stalk, was discovered at the city now called Leningrad, but we obtained it near Ward, in Colorado. Dr. Eugene Penard, the well-known Swiss authority on Protozoa, once visited Colorado, and collected in Boulder County a new

1. 2.

Shelled Protozoa
1. Difflugia rubescens Penard.
2. Difflugia fallax Penard.
After Penard. Much magnified.

species of *Difflugia*, remarkable for having the plasma of a beautiful red color. He named it *D. rubescens*. But returning to Switzerland, he found the very same kind of animal in that country. Dr. Sturgis in 1913 described a new slime-mold as *Fuligo megaspora*, found on Cheyenne Mountain, near Colorado Springs. The same thing was also found at Lake Albert Edward, in Central Africa. *Microcorycia flava* of Greeff, well-known in Europe and North America, living among mosses, is reported by Wailes from Brazil and Bolivia. In 1911 Dr. C. H. Edmondson collected Protozoa in the alpine lakes of Boulder, Grand, Gilpin and Clear Creek Counties, but although such lakes have furnished many peculiar mollusca, the Protozoa were like those found at lower altitudes and on the other side of the world. Some of the species were not identified, and it is possible, though not probable, that these may be in part peculiar to our mountains. A collection was made at 13,000 feet on Mt. Evans, and this is believed to be the highest recorded locality for Protozoa in North America.*

It results from the condition of affairs described that the determination of freshwater Protozoa is not always easy, since the species before us may have been described from almost anywhere on the earth, and it is necessary to consult the literature of the subject published in all the countries, and in many languages. In the majority of cases identification must be made from figures and descriptions of specimens which were not preserved, and if these were not sufficiently full and accurate, we are left in doubt. Nevertheless, with the aid of numerous modern works, such as those of Penard, Wailes, Edmondson and Conn, it is possible to make good progress, and the opportunities for such studies in Colorado are very great.

The Phylum Protozoa is usually divided into subphyla, distinguished by the modes of locomotion and reproduction. In the Mastigophora or Flagellata, locomotion is by a thread-like movable extension of the body called the flagellum. Not rarely there is more than one of these flagella. In the Sarcodina there

*University of Colorado Studies, vol. IX, May 1912.

is no flagellum, but the body may be temporarily extended in various directions. Such extensions, used for locomotion, are called pseudopodia, which means false feet in Greek. Another series, the Infusoria, moves by a great many relatively short hair-like movable processes, called cilia. These differences are not always clear; thus certain Infusoria lack the cilia when adult, and the curious genus *Deinamoeba* has both flagella and pseudopodia. Nevertheless, in nearly every case the distinction is clear enough, and the three groups can be recognized at a glance. There is a strong tendency among the Protozoa to develop parasitic forms, and this occurs independently in the different groups. Thus the parasite which produces dysentery is one of the Sarcodina; that which gives rise to sleeping sickness belongs to the Mastigophora. There is, however, a special subphylum, Sporozoa, consisting entirely of parasites, having usually no true organs of locomotion, and characteristically reproducing by division into a multitude of minute objects, the so-called spores. It is to this group that the malaria parasites belong.

Still another subphylum, the Mycetozoa or slime-molds, includes Protozoa adapted for life in air. They have been regarded by many as plants, and are described in botanical works, but on the whole they are best regarded as aberrant animals, genetically unrelated to the fungi or other lower plants. They produce spores, which give birth, in the presence of water, to swarm cells, which are minute flagellate objects. These swim about and feed on bacteria. After a time they join together and form a slimy mass called the plasmodium, which may often be found on damp logs. It is saprophytic, feeding on dead plant tissue. This usually becomes dry, and forms a sporangium, sometimes of considerable size. Thus the sporangium of *Reticularia*, found on trees, grows to four or five inches in diameter, and may be taken for a sort of puff-ball. From the sporangium come the spores, and the life-cycle begins again. These Mycetozoa are very abundant and varied in Colorado, where they have been carefully studied by Sturgis and Bethel.*

*If we regard the slime-molds as animals, the family-name Margaritidae, used independently by Doflein and the writer in 1911, cannot be employed, since the generic name on which it is founded is a homonym. For a similar reason, the family name cannot be based on *Dianema*. It remains only to use the name Prototrichiidae, based on *Prototrichia* Rost, though this is not very closely related to the others.

MASTIGOPHORA (FLAGELLATA)

These are divided into Phytomastigophora, in which plant characteristics are evident, and in some forms a covering of cellulose is secreted; and the Zoomastigophora, which are more definitely animals. Even in the latter we have such forms as the common *Euglena viridis*, which is green like a plant. Campbell, in his University Text-book of Botany (1907) says of the Flagellata (including *Euglena*) that they lie on the border between animals and plants, those with green chromatophores being able to assimilate carbon dioxide, like normal plants. As for the Phytomastigophora, including such genera as *Peridinium*, he boldly classifies them with the plants, remarking that they are excessively abundant in the sea, and are "the original source of food for nearly all marine animal life." It is interesting to think that one can dip a little water out of almost any stagnant pool, and find in it creatures so primitive that they still seem to stand at the crossroads, uncertain whether to enter the zoological or botanical domain. The slime-molds are not intermediate in this sense, for they constitute a specialized group leading to nothing else. Some of the Mastigophora might be thought of as in the line of ancestry of plants or animals, and since evolution has been in progress so many millions of years, we wonder why these primitive beings have remained almost unchanged. It must be because they have lived the simple life, occupying an environment well adapted to their needs, and for which their simple organization is well suited. Under such circumstances, natural selection is a conservative force.

SPOROZOA

Parasitic animals, of very diverse kinds. Here falls the genus *Plasmodium*, the cause of malaria, apparently not native in Colorado. The mosquito *Anopheles*, which carries the parasite to man, is absent from the greater part of the State, though abundant in portions of New Mexico. In 1922 Dr. Roy P. Forbes of Denver wrote reporting a case of quartan malaria at Denver in a baby seven weeks old. This is due to the sporozoan *Plasmodium malariae* of Laveran, which supposedly can only be injected into the body by a mosquito of the genus *Anopheles*. So far as we have ever been able to ascertain, there is no *Anopheles*

in the vicinity of Denver, but it is quite possible that a few specimens might be accidentally brought in on trains from Texas. The parasites were demonstrated by Dr. Forbes in the baby's blood, but also in that of the mother, a Greek woman who had a severe case of malarial fever five years ago in Greece. The question thus arises, could the baby have been infected through the placenta of the mother, or was it bitten by some accidentally imported mosquito?

Another group of Sporozoa is the Gregarinidae, parasitic in insects and other arthropods. In 1911 we remarked that they were doubtless numerous with us, "but none have been examined." A few years later Dr. Max M. Ellis took up the study of Colorado gregarines, and had no difficulty in finding a series of species, several of them new to science. *Stylocephalus giganteus* Ellis was found to be common in Tenebrionid beetles. *Amphorocephalus amphorellus* Ellis was found in the great centipede, *Scolopendra*. *Gregarina termitis* of Leidy was recorded from *Termes lucifugus*, but we now know that the termite was really *Reticulitermes tibialis* of Banks. *Gregarina rigida* of Hall was seen to be quite common in *Melanoplus* and other grasshoppers. *G. consobrina* Ellis was discovered in the orthopteran *Ceuthophilus*, taken in Boulder Canyon. *Stenophora robusta* Ellis occurred in diplopods at Boulder and Gold Hill. Although Dr. Ellis thus met with remarkable success in his search for gregarines, he did not more than begin to reveal the richness of our fauna in these parasites. Future workers, who will examine the alimentary canals of numerous insects, centipedes and myriapods, will undoubtedly make many additions to the list.

There are other Sporozoa which will certainly be found when looked for. For instance the genus *Nosema*, of the Microsporidia, exists in numerous species in many kinds of insects. It is *Nosema bombycis* of Naegeli which produces the famous pebrine disease of silkworms, studied by Pasteur. Some of the species exist elsewhere in genera of insects which are common in Colorado, but no one has searched for them here.

SARCODINA

These may be naked, as in the *Amiba*, or covered with a shell, as in numerous other genera. The common amoeba, found

everywhere in standing water, is probably to be called *Amiba diffluens* (*Proteus diffluens* G. Adams, 1787), though Doflein prefers to call it *Amoeba proteus* of Pallas. Penard found a peculiar *Amiba* on Bald Mountain, Boulder County, at 11,470 feet altitude. Later he received the same animal from Spitzbergen, and described it as *A. radiosa* var. *gemmifera.*

The shell-forming *Difflugia corona*, a rounded object with spike-like projections, has been made the subject of classical researches in heredity by Jennings. As the shells are readily preserved, many successive generations may be directly compared. This species, along with seventeen other members of the genus, was found in the mountain lakes of Colorado by Edmondson.

Quadrulella symmetrica of Wallich, found in Boulder County, but also widely distributed over the world, has the shell formed of quadrangular siliceous (flinty) plates, which will not dissolve in strong acid.

INFUSORIA

The species of ciliate Infusoria are extremely numerous, one of the most abundant being *Paramoecium caudatum* of Ehrenberg,* which has been used so much in studies of heredity, behavior, etc. It multiplies by division, and by starting with a single individual it is possible to develop a "pure line" of individuals all having the same ancestry. Paramecium may be found in great quantities in water in which cut flowers have stood. A few are of course present in the water drawn from the tap, but with the food supplied by the rotting stems, they multiply enormously.

A very handsome and remarkable infusorian is *Stentor coeruleus* of Ehrenberg, blue, and shaped something like a trumpet. The word stentor means a herald, and was suggested by the trumpet-like form. The animal is not rare at Boulder, and Edmondson found it in Redrock Lake near Ward.

Even the Infusoria have parasitic forms, and we have in Colorado a kind of *Opalina*, parasitic in the frog. This was not definitely identified, but was presumably *O. obtrigonidea* of Metcalf. *Protoopalina scaphiopodos* Metcalf is reported by its describer as

*Sherborn credits this name to J. Hermann, 1784.

being abundant in a spade-foot toad collected at Las Animas, Colorado. The toad belongs to the subspecies *Scaphiopus hammondii bombifrons* of Cope, with smooth skin and rounded muzzle. It appears that the typical, more western and southern *S. hammondii* has a different kind of parasite, which Metcalf calls *Protoopalina hammondii*. This suggests that the two forms of toad are really different species, and Metcalf so regards them.

Alphabetical Index

This index is intended to include the names of the principal genera of animals mentioned in the book, and also a number of the orders and families; individual species, except the more important ones, are not recorded either by scientific or English names. The names of individuals who have made collections or have done other zoological work in the State are listed, and a page reference, usually the earliest, is given.

Abert, J. J., 42
Aboriginal Man, 21
Acarina, 236
Accipiter, 73
Admiral, 211
Aedes, 181
Aeshna, 157
Agapostemon, 197
Age of Mammals, 16
Aglais, 210
Agriolimax, 134
Agrion, 156
Aiken, 56
Alces, 35
Allen, J. A., 56
Alticamelus, 20
Aluco, 74
Ambystoma, 3, 111
Amiba, 251
Amoeba, 251
Amphibia, 111
Amphipoda, 231
Anas, 63
Ancylus, 137
Andrena, 197, 204, 207
Angle-wings, 211
Annelid Worms, 245
Anopheles, 180
Anopleura, 146
Anser, 63
Antelope, 33
Antelope-squirrel, 44
Anthidium, 202
Anthophora, 204, 205
Anthropoid Primates, 20
Ants, 190
Aphididae, 163
Aphids, 165
Apis, 200
Aplexa, 137
Apus, 233
Aquila, 72
Araneida, 238
Archidiskodon, 19
Archilestes, 156
Archimyrmex, 7, 8
Arctiidae, 227
Argiope, 238
Argynnis, 209, 212
Armadillidium, 232
Asio, 74
Astacus, 231
Astragalinus, 85
Augochlora, 197
Avocet, 66
Axolotl, 111

Back-swimmers, 161
Badger, 30
Baker, F. C., 140
Bald Eagle, 72
Baldpate, 62
Basilarchia, 211
Bass, 126
Bats, 22, 23
Bear, 25, 26, 27
Beardsley, 105
Beaver, 47
Bed-bug, 161
Bee-flies, 184
Bees, 195
Beetles, 169
Benson, Elizabeth, 173
Bethel, E., 129
Bird Lice, 146
Birds, 56
Bison, 32
Biting Flies, 6
Biting Lice, 146
Bitterns, 64
Bivalves, 140
Black Bass, 126
Blackbird, 83
Black Flies, 180
Black-headed Snake, 108
Black Snake, 110
Blanchard, J. J., 23
Blattids, 147
Blissus, 160
Blister Beetles, 174
Bluebird, 99
Bluebottle Fly, 186
Blue Gill, 126
Blues, 222
Bobcat, 24
Bob-white, 70
Body Louse, 146
Bohemian Waxwing, 91
Bombomelecta, 204
Bombus, 198, 200, 204

Bos, 32
Bot-flies, 6, 185
Box-elder Bug, 160
Box-tortoise, 104
Brachystola, 150
Bragg, L. C., 166
Branchinecta, 234
Branta, 63
Brenthis, 212
Brontosaurus, 15
Brown Thrasher, 95
Bruce, G. T., 17
Bubo, 74
Buffalo, 32
Bufflehead, 62
Bufo, 112, 113
Bufonidae, 112
Bull-dog Ants, 7
Bullhead, 120
Bull Snake, 109
Bumble-bees, 198
Buprestis, 172
Burrowing Owl, 75
Burying Beetles, 176
Buteo, 73

Caddis-flies, 146
Calasymbolus, 225
Calico Bass, 126
Callospermophilus, 44
Cambarus, 231
Camels, 19, 20
Camponotus, 191
Camp Robber, 82
Canada Lynxes, 16
Canis, 25
Cannon, G. L., 104
Cantharidae, 175
Carnivora, 23
Carps, 121
Carrion Beetles, 176
Cary, Merritt, 23
Castanet Grasshopper, 150
Castor, 47
Cat-bird, 95
Caterpillars, 227
Catfishes, 120
Cats, 24
Cave Crickets, 149
Cedar Waxwing, 91
Celerio, 225
Centipedes, 235
Ceratina, 197
Cervus, 34
Ceryle, 76
Cestodes, 242
Chat, 92
Checkered Beetles, 175
Chen, 63
Chermes, 165
Chilopoda, 235
Chinch-bug, 160
Chipmunk, 38, 44, 45
Chloripppe, 14, 209, 212
Chrysemys, 105
Chrysomela, 170
Chub, 123
Cicadas, 161
Cimex, 161
Circotettix, 150
Citellus, 42
Cladocera, 232
Clams, 140
Clarke's Crow, 82
Coccidae, 166
Cockerell, Mrs., 14
Cockerell, T. D. A., 36
Cockroaches, 147
Coelenterata, 246
Coleoptera, 169
Collembola, 144
Colletes, 201, 207
Conchostraca, 233
Cook, Harold, 24, 26
Cooke, W. W., 56
Coots, 65
Cooper's Hawk, 73
Cope, 10
Copepoda, 232
Cotton-tails, 54
Cotton-worm Moth, 228
Coues, Elliot, 28, 102
Cow-bird, 83
Coyotes, 25
Crane-flies, 179
Cranes, 65
Crayfish, 231
Creeper, 97
Cricket, 148
Crotalus, 108
Crotaphytus, 107
Crows, 81
Crustacea, 231
Cuckoos, 76
Culex, 181
Culicidae, 180
Curlew, 67
Custer, Clarence, 194
Cyclops, 232
Cyllene, 173
Cypris, 232

Dace, 118, 122
Damsel-flies, 155
Danaus, 213
Darter, 125

Decapoda, 231
Deer, 34
Deer Mice, 50
Dendroica, 93
Dermacentor, 237
Diadasia, 201
Diaptomus, 232
Dickcissel, 89
Difflugia, 248
Dings, Max, 212
Dinosaurs, 15, 104
Diplopoda, 235
Dipodomys, 47
Dipper, 95
Diptera, 178
Dissoteira, 150
Diving Birds, 59
Dodge, 213
Dog Family, 25
Domestic Fowl, 69
Dodds, G. S., 234
Dove, 71
Dragon-flies, 145, 154
Drone-flies, 184
Drosophila, 8
Duce, J. T., 4
Ducks, 61
Dusky Grouse, 56

Eagles, 72
Earthworms, 245
Echinodermata, 240
Edmondson, C. H., 248
Eel, 124
Egrets, 64
Eider, 61
Elephants, 17
Elephas, 18
Elk, 34
Ellis, Howell 124
Ellis, M. M., 113
Engle, E. T., 231
English Sparrow, 85
Entomostraca, 234
Eohippus, 17
Eomyza, 8
Epeira, 238
Ephydatia, 246
Ergates, 173
Ermine, 29
Estheria, 233
Euconulus, 132
Euglena, 250
Eurymus, 217
Eutamias, 38, 44
Evening Grosbeak, 84

Fairy Shrimps, 233
Falco, 72
Felis, 24
Ferrets, 28
Ferrisia, 137
Ferriss, 139
Figgins, 4
Fishes, 114, 118
Flagellata, 248
Flat Worms, 242
Flickers, 76
Flies, 178
Florissant Shales, 7
Flower-flies, 184
Fluke, 242
Flycatchers, 79, 80
Forbes, Roy P., 250
Formica, 191, 192
Formicidae, 190, 191
Fossil Birds, 58
Fossil Horse, 4
Foster, Elsie, 219
Fox, 25
Fremont, Gen. J. C., 42
Frey, J. W., 123
Frick, 25
Frogs, 112
Fruit Fly, 187
Fuligo, 248

Gad-flies, 185
Gadwall, 62
Gaige, F. M., 124
Gale, Scott, 179
Gall Flies, 189
Gall-gnats, 181
Gammarus, 232
Garpike, 6
Garter Snakes, 108
Gastrocopta, 133
Geese, 60, 63
Geometridae, 229
George, R. D., 18
Gill, Miss M., 146
Gillette, 151
Gillettea, 164
Glossina, 12
Gnatcatcher, 98
Gnats, 179
Goats, 33
Godwit, 68
Golden Eagle, 72
Golden-eyes, 62
Goldfinch, 56, 85
Goldfish, 121
Goose, 63
Gopher, 37
Goshawk, 73
Grackle, 83

Grasshoppers, 149
Grass Sparrows, 86
Grebes, 59
Greenbottle-fly, 186
Green River Shales, 185
Green Snake, 109
Green Sunfish, 126
Gregarinidae, 251
Grinnell, G. B., 58
Grosbeak, 84, 88
Ground Beetles, 177
Ground-sloth, 20
Ground Snake, 109
Ground Squirrel, 43
Grouse, 69, 71
Gryllus, 148
Gulls, 59

Hair-streaks, 222
Halictus, 197, 206
Hall, Maurice C., 243
Halter, 13
Hares, 53
Harlequin Duck, 63
Harlequin Grasshopper, 153
Harvest Mice, 50
Harvest Spiders, 239
Hawk, 73
Hayden, F. V., 27
Head Louse, 146
Hebard, M., 152
Hell-diver, 59
Helmer, George, 18
Hemiptera, 159
Henderson, J., 11
Henshaw, H. W., 108
Herons, 64
Hesperopithecus, 20
Hesperotettix, 153
Hetaerina, 156
Heteroptera, 159
Hicks, C. H., 195
Hite, Glenn, 156
Holbrookia, 107
Holman, T. B., 167
Homoptera, 159
Homo Sapiens, 16, 21
Hoofed Mammals, 32
Hoplisus, 7
Horn Fly, 187
Horned Lark, 80
Horned Toads, 106
Horntails, 188
House Finch, 56
House Fly, 179, 186
House Mouse, 37
Hover-flies, 184
Hubbard, Ralph, 48
Hubbs, 124
Humming-birds, 78
Hydra, 246
Hydrozoa, 246
Hylaeus, 207
Hylidae, 112
Hymenoptera, 187
Hypochlora, 154

Ibises, 64
Ichneumon-Flies, 189
Infusoria, 252
Ingersoll, 138
Insectivores, 22
Insects, 143
Isopoda, 232
Isoptera, 145

Jack-rabbits, 54
Jaeger, 59
Jays, 81
Johnson, Georgia, 176
Jones, C. R., 185
Juday, 122
Junco, 87

Kangaroo Rats, 47
Killifishes, 124
Kingbird, 56, 79
Kingfisher, 76
Kinglets, 98
King Snake, 109
Knudsen, S., 200

Lacewing Flies, 145
Lacy, Louise, 17
Lady-beetles, 171
Lagopus, 71
Lake Florissant, 10
Lamellicorn Beetles, 172
Lark Bunting, 89
Larva of Apollo Butterfly, 215
Lasius, 191
Lazuli Bunting, 56, 89
Leach, C. F., 220
Leech, 246
Lepidosteus, 6
Lepidurus, 233
Leptinotarsa, 169
Lepus, 54
Lesquereux, 10
Leucosticte, 84
Libellula, 158
Lice, 146
Lidle, E. A., 20
Limax, 134
Limnopus, 3
Lithobius, 236

Lithohypoderma, 6
Little Red-fin, 124
Lizards, 105, 106, 107
Locust, 150
Locustidae, 149
Longicorn Beetles, 173
Long's Expedition, 44
Longspur, 85
Loons, 59
Louse, 146
Lubber Grasshopper, 150
Lumbricus, 246
Lutz, F. E., 161
Lycaenidae, 222
Lycosa, 239
Lymnaea, 136, 137
Lynx, 24

Magpies, 56, 81
Mallard, 63
Mammals, 15
Mantis, 148
Markman, H. C., 233
Marmota, 40
Marquettia, 14
Marsh Hawk, 73
Marsupials, 8
Martens, 29
Martin, 90
Mason, Guy, 232
Mason, J., 228
Mastigophora, 248
Mastodon, 17
Maxson, A. C., 229
May-flies, 146
Meadowlark, 82
Mealy-bugs, 166
Mearns, E. A., 103
Megachile, 198, 203
Melanoplus, 151
Melissodes, 201, 204, 205
Melitoma, 198
Merganser, 60
Merriam, 26
Mice, 48, 49, 50
Microphysula, 132
Microtus, 37
Milkweed Butterfly, 211, 213
Miller, F. W., 31
Millipedes, 235
Minnows, 121
Miocene Shales, 9
Mites, 236
Mniotilta, 92
Mocking Bird, 95
Modern Man, 16
Mole, 23
Mollusca, 127
Morrison, H. K., 202
Mosquitoes, 180
Moths, 224, 225
Mottled Duck, 63
Mountain Goat, 33
Mountain Sheep, 33
Mourning Cloak, 209
Mud-daubers, 194
Mud Turtle, 105
Mus, 38, 52
Musca, 186
Musk Rat, 51
Mustela, 28, 29
Mycetozoa, 249
Mylodon, 20
Myrmecocystus, 191

Nadabius, 236
Neanderthal Man, 16
Nematides, 243
Nemestrinid Fly, 183
Neotoma, 49
Neuroptera, 145
Newton, J. H., 135
Night-hawk, 78
Noctuidae, 228
Noctuids, 228
Nomada, 197, 198
Nomia, 204
Norway Rat, 37
Notostraca, 233
Nuthatch, 97
Nuttall, Thomas, 101

Odocoileus, 34
Oil Shales, 5
Oligochaeta, 245
Oreohelix, 128
Ornithology, 56
Orthomorpha, 235
Orthoptera, 147
Oryctolagus, 54
Osborn, H. F., 20
Osmia, 203
Osprey, 72
Ostracoda, 232
Otospermophilus, 42
Otus, 74
Oven-bird, 93
Ovis, 33
Owl, 74
Oxyuris, 243

Pachysphinx, 225
Painted Turtle, 105
Palmer, 33
Papilio, 213
Parahippus, 4, 17

Parajulus, 235
Paramoecium, 252
Parelephas, 19
Paroquet, 75
Peale, A. C., 9
Pelican, 60
Pemphigus, 164
Penard, Eugene, 247
Pediculus, 146
Perdita, 196
Perodipus, 38
Perognathus, 47
Peromyscus, 37
Phalarope, 66
Phalangida, 239
Pheasants, 69
Phoebe, 80
Phrynosoma, 106
Physa, 137
Pieridae, 216
Pieris, 219, 220
Pigeon, 56, 71
Pikas, 39, 53
Pike, Zebulon, 56
Pileolted Warbler, 94
Pill-bugs, 232
Pine Siskin, 85
Pinyon Jay, 82
Pintail, 62
Pipit, 94
Pisidium, 141
Planarians, 242
Planesticus, 99
Planorbis, 137, 138
Plant-bugs, 159
Plant Lice, 163
Plasmodium, 250
Plovers, 66, 67
Pocket Gophers, 46
Pocket Mice, 47
Porcupine, 53
Porifera, 246
Prairie Chicken, 71
Prairie-dogs, 40
Prairie Rattlesnake, 108
Primates, 21
Primitive Mammal, 15
Printz, 37
Procyon, 27
Protozoa, 247
Protura, 144
Pupilla, 133
Putnam, J. D., 162
Putorius, 29
Pseudacrist, 113
Pseudoscorpions, 239
Psithyrus, 204
Ptarmigan, 71
Pygmy Owl, 75
Pyralidae, 229

Quails, 70

Rabbits, 39, 53
Raccoon, 27
Rails, 65
Ramaley, Francis, 11
Rana, 113
Ranidae, 112
Rats, 48, 49
Rattlesnakes, 108
Rattus, 52
Raven, 56, 81
Reakirt, 215
Redpoll, 85
Redstart, 92
Rhodites, 189
Rhopalomyia, 182
Rhynchtherium, 17
Ridgway, 56
Ring-necked Pheasant, 71
Ring-necked Snake, 109
Ring-tail, 28
Road Runner, 56, 76
Roan Creek, 5
Roan Mountains, 6, 10
Robber-flies, 184
Robbins, W. W., 197
Robin, 56, 57, 99
Rock Bass, 126
Rock Squirrel, 44
Rodents, 36
Rohwer, F. W., 158
Rohwer, G. N., 12
Rohwer, S. A., 13
Rosy Finches, 84
Rotifera, 244
Round Worms, 243
Ruddy Duck, 63
Ruffled Grouse, 71

Sage-hen, 71
Sage-thrasher, 95
Salamander, 111
Sanderling, 67
Sandpipers, 66, 67
Sarcodina, 251
Sawflies, 188
Say, Thomas, 56, 101
Scale Insects, 166
Scarlet Mites, 237
Sceloporus, 107
Sciurus, 42
Sclater, P. L., 95
Sclater, W. L., 59
Scorpions, 239

Screech Owl, 75
Scudder, S. H., 9
Scutigera, 236
Sea-urchin, 240
Selasphorus, 78
Sharp-shinned Hawk, 73
Sheep, 33
Shotwell, R. L., 169
Shrews, 23
Shrike, 91
Sialia, 98
Silverfish, 144
Silver Spots, 209, 212
Simpson, C. T., 140
Siskin, 85
Sistrurus, 108
Skink, 105
Skippers, 222
Skua, 59
Skunks, 31
Slugs, 134
Smerinthus, 225
Smith, H. G., 105, 216
Snails, 127
Snakes, 108
Snapping Turtle, 105
Snipes, 66, 67
Snow Birds, 87
Snow Bunting, 85
Snow-goose, 63
Snowshoe Rabbit, 54
Snowy Owl, 75
Soft-shell Turtle, 105
Soldier-flies, 183
Solpugids, 239
Song Sparrow, 88
Spade-foot Toad, 112
Sparrow, 80, 86
Sparrow-hawk, 73
Spermophiles, 42
Sphecodes, 201
Spiders, 238
Spider Wasps, 194
Sphinx Moths, 225
Spoonbill, 64
Sporozoa, 250, 251
Spotted Fever, 236
Spotted Fever Tick, 237
Spring-tails, 144
Squash Bug, 160
Squirrel, 41
Stentor, 252
Stick-insects, 147
Stilt, 66
Stoats, 28
Stone-flies, 145
Stone-roller, 121
Strange, E. A., 18
Striped Lizards, 106
Sturgis, 248
Sturnella, 82
Succinea, 133
Suckers, 120
Sugar-beet Leaf-hopper, 162
Sugar-beet Webworm, 229
Sutton, Clement, 175
Swainson's Hawk, 74
Swallow, 56, 90
Swallow-tails, 213
Swans, 60
Swift, 78
Swifts, 107
Sylvilagus, 54

Tamalia, 164
Tanager, 89
Tape-worms, 242
Teal, 62
Tegeticula, 229
Teleoceras, 19
Terns, 59
Tetralonia, 197
Tetraopes, 173
Theobaldia, 181
Thrasher, 95
Thrush, 96, 99, 100
Thysanura, 144
Ticks, 236
Tiger Beetles, 178
Tiger Salamander, 3
Tipula, 179
Titanotheres, 19
Titmouse, 97
Toads, 112
Todd, Miss A. O., 227
Tortoise-shell, 210
Tortoises, 105
Towhees, 88
Tree Frogs, 112, 113
Tree-hoppers, 162
Trichinella, 243
Trichobius, 187
Trigonias, 19
Trilophodon, 17
Trout, 118
Trumpeter Swan, 64
Tsetse-flies, 12, 187
Turkey Vulture, 72
Turkeys, 56, 70
Turnstone, 66
Turtles, 105
Tyrannus, 79
Tyto, 74

Ungulates, 32
Ursavus, 25
Uta, 107

Valvata, 136
Vanessa, 209
Velvet Ants, 194
Vermes, 241
Vesper-Sparrow, 86
Violet-green Swallow, 90
Vireos, 91
Virtigo, 133
Vitrina, 132
Vole, 37
Vulture, 72

Wagner, C., 189
Wagtail, 94
Wall-eyed, Pike, 125
Warblers, 92, 93, 94, 98
Warmouth Bass, 126
Warren, B. E., 236
Warren, E. R., 26
Wasps, 193
Water Beetles, 177
Water-bugs, 161
Water Fleas, 232
Water Ouzel, 95
Water-scorpions, 161
Water Shrew, 23
Water Snake, 109
Waxwing, 90
Weasels, 28
Weevils, 174
Wheeler, Alfred, 176
Whistling Swan, 64
White-ants, 145
White-crowned Sparrow, 86
Whitefish, 119
White-flies, 163
Wickham, H. F., 14
Wild Canary, 93
Willet, 68
Wilson, Alexander, 101
Wolf-spiders, 238
Woodchuck, 40
Woodcocks, 66, 67
Wood Duck, 62
Wood-lice, 232
Woodpeckers, 76, 77
Woolly Aphis, 165
Worcester, P. G., 114
Worms, 241
Wren, 56, 96

Xenoglossa, 201

Yellow Jacket, 193
Yellow-legs, 68
Yellow Perch, 125
Yellow-throat, 94
Yellow Warbler, 93
Young, Dorothy, 156
Young, R. T., 43

Zebra Fish, 124

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